THIRTEENTH ANNUAL CONFERENCE OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

COLUMBUS, OHIO, OCTOBER 14, 1918

FIRST SESSION

Assembly Room, Chamber of Commerce, October 14, 1919, 2.00 p.m.

The meeting was called to order by President Stocking who welcomed the members to the meeting and expressed the regret that the attendance was comparatively small which was due to the influenza situation.

Professor Bouska moved that the roll call be taken at the banquet. This motion was seconded and carried.

As the minutes of the previous meeting had been published in the AMERICAN JOURNAL OF DAIRY SCIENCE it was moved by Professor Reed that the reading of the minutes of the previous meeting be omitted. Motion was seconded and carried. The members responding to the roll call in the evening were as follows:

C. M. Long
L. Dains
C. R. George
W. D. Nicholls
J. H. McClain
C. W. Larson
H. W. Norton, Jr
J. G. Winkjer
J. H. Frandsen
O. A. Jamison
C. W. Rodway
D. L. James
W. P. B. Lockwood
E. M. Clark
C. S. Rhode
Helmer Rabild
A. C. Anderson
G. E. Frevert
E. V. Ellington
J. D. Jarvis
J. Gamble
G. L. Bulkley
C. M. Cummings
M. Mortensen
W. O. Nills
J. B. Fills
A. C. Ragsdale
Thos. C. Reed
R. F. Flint
Roy C. Potts
C. C. Hayden
O. Erf
O. F. Hunziker
W. B. Nevens
Wm. White
V. R. Jones
W. L. Ginnis
W. W. Yapp
N. E. Olson
W. A. Stocking
H. H. Kildee
O. E. Reed
R. R. Graves
R. B. Stoltz
DeVoe Meade
R. D. Canan
F. W. Bouska
F. W. Atkeson

A report of the Committee on Official Methods for Testing Milk and Cream for Butter Fat was called for. Prof. O. F. Hunziker, Chairman, reported that the Committee had been unable to prepare a joint report on account of the influenza situation and he suggested that Prof. F. W. Bouska present an informal report. The following report was presented.

A Contribution to the Study of Testing Buttermilk

I frequently observe buttermakers who believe they are doing unusually exhaustive churning because their test of their buttermilk shows only 0.03 to 0.10 per cent of butterfat. When I have an opportunity to test this buttermilk I usually find 0.20 to 0.40 per cent and occasionally even more. Buttermilk which I have found to test 0.40 per cent shows over 0.90 per cent by the extraction method. The Babcock method, applied the usual way, shows only the smaller part of the fat contained in buttermilk.

I use the following modification of the test which shows more butterfat and is more correct than the usual method. Nine cubic centimeters of buttermilk is measured into a skimmilk bottle. Enough sulphuric acid is added to give the fat column an amber color. About 15 cc. will usually do this. The bottle is so placed in the centrifuge that the small neck travels foremost. This avoids possible spilling of butterfat in the last whirling. It is whirled fifteen minutes at the utmost safe speed. Hot water is added to the base of the neck and a two or three minute whirling is given. Hot water is added so the column could be read. A drop of water is placed on top of the small neck. The whirling forces it through the fat thus washing it and helping to make the test clearer. After whirling one minute the test is read and the reading is doubled.

Although this method brings more butterfat into the neck of the bottle than the usual method and is in every way superior to the usual method, it is of little value in determining the total quantity of fat lost in the buttermilk. This intense method of testing, if uniformly carried out, shows relative losses and adequately shows whether the churning is as exhaustive as it is practical to make it.

The intense method can not be fully carried out in an electric tester because of lack of heat and inability to increase speed. To ascertain if amyl alcohol would be of service in an electric tester, I added 1 cc. of amyl alcohol before adding sulphuric acid. The tests were re-

markably clear and read close to extraction determinations. The question arose whether the amyl alcohol directly increased the volume of the fat column. A blank of alcohol, water and acid gave a reading of 0.06 per cent and the column looked exactly like butterfat. A similar blank to which dry butterfat to the equivalent of 0.17 per cent had been added gave a reading of 0.40 per cent. Amyl alcohol therefore directly increases the volume of the fat.

The remarkably clear readings give me hope that some way of adapting amyl alcohol to the testing of buttermilk can be worked out.

The Rose-Herzfeld (Gottlieb) method has not been uniformly satisfactory in our hands. Emulsification sometimes occurs and makes it difficult to see the lower line of the fatty solution.

Fat solvents are not able to completely extract the fat from a product which has dried into a solid mass having a horny consistency. The crust of casein and albumin is insoluble in fat solvents and thus protects the encased fat.

I submit a related letter from Professor Farrington:

Madison, Wisconsin,
September 27, 1918.

Mr. F. W. Bouska
Amer. Assn. Creamery Butter Manufacturers
Suite 2037 Cont. & Com. Bank Bldg.,
Chicago, Ill.

Dear Mr. Bouska:—I have yours of September 25th, and note your investigation of the subject of testing buttermilk and skim milk. I think you are right in regard to the difficulty of getting an accurate result in testing buttermilk, but few people realize that it is even more difficult to test than skim milk, and that many of the results reported do not represent the actual amount of butterfat in the buttermilk. I am interested in the work you are doing and in the suggestions you make concerning the use of the Gottlieb method. I think your suggested use of Amyl alcohol will be all right provided you can be sure that each lot of Amyl alcohol used is completely volatilized at the temperature of the fat when the test is made.

In some of the very early work I did with the Babcock test about twenty-five years ago I noticed that in using the old Beimling test, that a higher reading of something that looked like fat in the neck of a test bottle was obtained by this method, when skim milk was tested than was the case when the same sample was tested with the Babcock test. I found by various trials that in making a blank determination, that is, using nothing but the reagents, one of which was amyl alcohol, and performing the test according to directions on a pipette full of clean water, that I always obtained a certain amouut of a yellowish liquid in the place of the butterfat in the neck of the test bottle. This I found was a residue, probably a heavy alcohol or an impurity which occurred in the amyl alcohol, and it seemed to be a liquid which failed to completely evaporate by the heat generated

in making the test; I think, therefore, your suggestion about using a small quantity of amyl alcohol in testing buttermilk and skim milk will be all right, if a test for each lot of amyl alcohol used for this purpose shows that it contains no impurities, which fail to evaporate when used in making a test.

I shall be pleased to hear from you again in regard to this matter as it is one in which I am interested, and I trust that both yourself and Professor Hunziker will suggest some refinements that will make tests of skim milk and especially buttermilk, particularly in the hands of a novice, or even the average tester more successful than is the case at the present time.

Yours truly,

(Signed) E. H. FARRINGTON,
Dairy Department.

Discussion

Professor Hunziker added that the experience of Bouska and Farrington had also been his experience. He had conducted a series of experiments comparing that with the gravimetrical analysis. The results obtained were very unsatisfactory and he suggested that some modification of the Babcock test be made and that the work of this Committee be continued.

Professor Gray inquired in reference to the real value of determining the least trace of fat as the least trace cannot really be recovered. He expressed it as his experience that the test if operated in the regular way will recover what we will obtain in our practical work and he considers the main thing which we desire to know is how much we are losing that can be recovered. Any further than that the advantage would seem rather questionable.

Question: Did you make any analyses microscopically?

Professor Bouska answered that he had made no analyses microscopically, but he had found much of the fat was enclosed in the casein and that he considered the buttermilk test to be of very little value in determining the fat that was commonly lost in the buttermilk and skim milk. He desired to have some method by which we can definitely determine the amount of butter fat received and the amount lost so as a result thereof a complete check may be introduced in our creamery operations. The intense method as has been reported by the Committee is adequate. Some buttermakers are of the belief that they are doing good work by not testing buttermilk or skim milk effectively and therefore the unskilled man does not realize his own deficiency.

Professor Hunziker states that his experience has been that the ordinary test of skim milk is merely approximate. It does not get but a trace of the fat present and for that reason it is not reliable.

Moved by Professor Hunziker that the report be accepted and placed on records of the Association. Motion was seconded and carried.

Report of Committee on Relation to Breed Associations was called for. Professor Eckles, Chairman, was not able to be present on account of the influenza situation. He wrote a letter explaining why he was unable to be with us and requested that the report be given by Professor Rassmussen or Professor Hunziker. As Professor Rassmussen was also absent it was suggested by Professor Hunziker that this report be left over until the next meeting when Professor Eckles would be able to be present and present the report. In accordance with this suggestion it was decided by the President that this report be presented at our next meeting.

Report of the Committee on Statistics on Production and Marketing of Dairy Products was called for. Professor Roy C. Potts, Chairman. Professor Potts informed us that in accordance with his suggestion at the conference at Amherst, Mass. this Committee was appointed at Springfield and that it had not been possible for the Committee to get together as much as would have been desirable. Report follows:

Statistics of Production and Marketing of Dairy Products

In the preliminary report of this Committee which was made to your Association at its Annual Meeting held in this city one year ago, the statement was made in the concluding paragraph of the report that "Suggestions may be offered in a future report, dealing with the interpretation, application, and practical use which may be made by the Dairy Industry of the statistics compiled and issued by the Bureau of Markets of the United States Department of Agriculture." It will be the purpose of this report to follow the suggestions offered in the previous report and to discuss the interpretation, application and practical use of statistics compiled by the Bureau of Markets on the production and marketing of dairy products.

Since rendering the previous report the Bureau has made considerable progress in compiling statistics on the Dairy Industry, and as the Chairman of your Committee is in charge of the Dairy Marketing work in the Bureau of Markets, he is closely in touch

with the development of that work, and it may be of interest to you to know the purpose or primary object of that work.

The statistical work as conducted is largely a supplementary part of the market report service work on dairy products which has for its primary object the furnishing to producers, distributers and consumers of dairy products accurate and reliable fundamental facts and information in regard to the supply, demand, market prices and market conditions which would enable them to market, distribute, and purchase dairy products intelligently, efficiently, and economically. Before the Bureau of Markets undertook its market news service work on dairy products there was very little statistical information available of a basic or fundamental nature in regard to supply and demand, and business in general was greatly handicapped thereby. In conducting the market news service on dairy products every effort is being made by the Bureau to ascertain correct and reliable data in regard to the production, the available supplies both as private stocks in the hands of the distributing trade and stocks in public warehouses and cold storages, also the existing demand for these as well as the rate of consumption. In this connection it is well to emphasize the importance of knowing the rate of consumption of a commodity like creamery butter and the supplementary factor, rate of production, for unless production and consumption go hand in hand there is apt to occur an over production or an under supply, with the former resulting in low prices to producers and the latter in high prices to consumers, both of which should be avoided if possible by the maintenance of a proper relation of production and consumption through the medium of prices which will stimulate on the one hand the largest production commensurate with fair returns to the producer and on the other, the largest consumption with the products going to the consumer at reasonable prices over the costs of production plus a fair profit to producers and a reasonable margin to distributers.

With this statement of the fundamental purpose of statistics on production and marketing of dairy products we will review a concrete case of the application of such statistics as are being compiled as the means of pointing out the application and practical use which may be made by the Dairy Industry of the statistics now being compiled.

We are at present at war and if "Food will win the war," as is oft repeated, then it becomes incumbent upon our own people to see that adequate supplies are provided of every class of food upon which our Allies and our own Nation must depend, and of which the principal

source is in our own country. We will take for example the question of our cheese situation, since it lends itself so well to an analysis for our purpose. In making an analysis of the cheese situation, three vitally important questions may be asked: First, what is our present rate of production of cheese in our country? Second, what is the present rate of consumption of cheese in our country? Third, what is the relation of production and consumption to our available surplus supplies, and at these rates when will our present surplus be exhausted and how much of it can be spared for our Allies and for overseas shipments to our fighting forces? To answer the latter question it is evident that we must be able to answer the first two questions and know the amount of our surplus stocks. We must not only know this information for the present year but the preceding year, and if possible for as many preceding years as it is available. Due to the fact that such statistics as would enable us to answer these questions have only been compiled during the past two years we must base our calculations or analysis of the cheese situation upon data for the years 1917 and 1918.

A careful study of the statistics which I will now present to you shows that not only has our production of cheese decreased approximately 1,000,000 pounds per month, but that consumption has increased approximately 7,000,000 pounds per month for the year 1918 as compared with the year 1917. The stocks in storage for the present year since July 1, have been considerably below those of last year, and the October 1 report of the Bureau of Markets, which was released only a few days ago, showed 57 per cent less cheese in storage than there was a year ago, and it is of interest to note that during the month of September, 1917, there was an increase in the stocks of cheese in storage of 2.7 per cent, or over 2,350,000 pounds, while during the month of September of the present year the stocks decreased over 23 per cent, or approximately 13,000,000 pounds. It is true that during the month of September, 1918, the export movement has been considerably heavier than during the month of September, 1917, but the decrease in stocks cannot be attributed entirely to the export movement, for increased consumption of cheese with the decreased production accounts primarily for the extreme shortage in cheese stocks at the present time. In this connection it is of interest to note that during the past three weeks prices of cheese have been constantly mounting higher, with an aggregate increase during this period of approximately 6½ cents in the primary markets of Wisconsin.

In the report of this Committee presented to your Association at its conference last year, the method employed by the Bureau in securing statistics on production and storage stocks was carefully outlined. The reports of exports are at the present time compiled by the Customs offices of the Treasury Department and are issued through the Bureau of Foreign and Domestic Commerce of the Department of Commerce. Through arrangements between the Bureau of Markets and the Bureau of Foreign and Domestic Commerce, statistics are now available showing exports and imports by 10-day periods, and these are available to any members of this Association who desire them and make request of the Bureau of Markets.

Referring to the statistics on page 265, it will be noted that the production during the first six months of 1917 was approximately 6,000,000 pounds more than for the first six months of 1918, which clearly shows that the production for 1918 was about 1,000,000 pounds less per month than during the corresponding period in 1917. If we add to the stocks in storage on January 1 of each year the production during the succeeding six months and subtract from that amount the stocks in storage on July 1 of each year, also the exports during the six months period, we have figures showing the domestic consumption for the six months period of each year. It will be readily noted that the increased monthly consumption in 1918 approximates 7,000,000 pounds per month. Carrying our analysis still further into the year 1918 and referring to the figures given on page 265, it is evident that there will be insufficient supplies of cheese for our civilian population, to say nothing about the needs of our overseas forces and our Allies.

No analysis is complete that does not take into consideration the international trade relations and the surplus stocks of other countries available for export. The principal sources of cheese of the cheddar type are Australia, New Zealand, Argentina, Canada, and the United States. Argentina and Canada are large producers for the English market, and stocks from those countries have been moving overseas quite freely of late. It is reported that the surplus stocks of cheese in Australia available for export on August 1 were 175 tons (long tons) and in New Zealand 21,000 tons. The 21,000 tons in New Zealand amount to approximately 47,000,000 pounds, which is more than our total surplus stocks in this country in cold storage.

I will not dwell longer upon our cheese situation, for I am sure that you appreciate the application and practical use of such statistics as the Bureau of Markets is now compiling in analyzing the cheese situa-

tion, also in answering the three questions which I have mentioned. But the data which I have presented represent by no means all of the available data which the Bureau of Markets is compiling with reference to the cheese industry. In our Daily Cheese bulletins which are issued at our branch offices and the Weekly Cheese bulletins, additional data are presented which should be of interest and value to one desiring to keep closely in touch with the current production and market demand for cheese.

It may be somewhat new to some of you to undertake a study of any branch of the Dairy Industry from the marketing standpoint, but it ought to be evident that without such data and statistical information as is compiled by the Bureau of Markets it would be possible to make but very little progress in marketing studies, or in the issuing of reliable and accurate reports.

I have frequently been asked to explain the purpose of the statistical data which is presented in our daily market reports, and if you are asked a similar question I trust that should you be unable to give a satisfactory explanation that you will not hesitate to write to Washington and request it.

The question is frequently asked: Are the reports issued by the Bureau of Markets of value to producers of dairy products, and my answer is that they will only be of value as producers learn to use them. As teachers and dairy extension workers, I feel that you who are members of the American Dairy Science Association have an opportunity to render a very valuable and useful service to the Dairy Industry by carefully studying the daily market reports issued by the Bureau of Markets and by explaining to interested parties the application and practical use of them.

I do not know what the desires of this Association may be with reference to continuing the work of this Committee. Personally I feel that there is much yet which the committee may be able to do which will be of interest and value to the members of this Association, and in future report there may be presented a discussion of the statistics on the international trade in dairy products.

Moved by Professor Gamble, seconded by Frandsen, that the report be accepted and placed on records of the Association. Motion carried.

Discussion

Professor Anderson asked if figures would be available so as to include information as to anticipated increase or decrease monthly by comparison from year to year.

Professor Potts answered that these reports should become more valuable from year to year as we today did not know whether the conditions were normal or not as the work is new and as the conditions are abnormal at the present time on account of the war. When these reports were first issued the dealers did not know what the normal stock was and it is only from continued work that such reports become of value. Professor Potts furthermore suggests that the school should consider such work before their classes as the reports contain information which should be of much value to the technical dairy students.

Professor Frandsen: Are there any statistics about market milk comparing this year's business to that of previous years?

Professor Potts: No. It will have to be carried on in much the same way. It will be necessary to place in the city market men who will obtain information about demand and supply. We are at present compiling a monthly report of prices paid to producers and retail milk prices. These are yet in an experimental stage and are not ready to be put out, but we hope to secure a man who can work along these lines so such information may be furnished.

Professor Hunziker: I have been impressed by the information from the Bureau of Markets. The reports published by this Bureau have been of much value to the manufacturers of the United States.

Professor Potts informed the Association that the American Butter Manufacturers Association was also issuing a report and he has suggested to Dr. McKay that they cooperate as the figures which they have already obtained may be of much value as a guide to the manufacturers of the United States.

Professor Anderson maintained that cheese is a seasonable product. He says that the reports of the Bureau of Markets have been most valuable.

Professor Hunziker: I want to emphasize the value of these statistics as it has never been possible before to secure such figures. I would like to ask if there has been anything done to get figures of export and imports.

Professor Potts: Professor Potts was of the opinion that through the state departments it will be possible to obtain international infor-

mation in the near future and it is the intention after the war to add to the present information daily reports of exports and import movements. The Bureau of Markets is furthermore sending inspectors to standardize our system of scoring. They will all work together in New York City and then work among the various markets so that the scores from the New York market and the Chicago market will be the same for goods of the same quality. By that system the market inspectors report will not be questioned by any court, but it will be accepted by all.

Professor Hunziker: I am wondering if the Bureau of Markets in considering the standardization of scoring of butter is also considering when scoring for quality the relation of such quality to keeping quality as the scores given on butter today do not always serve as an accurate index of the keeping quality of the butter and as long as it is so it is wrong. The quality that endures is the quality that keeps. Butter may score 98 and still be poor butter when it comes to consumer.

Professor Potts: The Bureau of Markets will take into consideration every phase of the work. The manufacturers certificate may also have to be considered, as to how it is manufactured and the quality of goods used. If this proves to be necessary, such information will not be added to the score but will be given on a separate report.

A report of the Committee on Methods of Conducting Student Dairy Products Judging Contest was called for. As Mr. Thompson, on account of illness, was unable to be present Professor White was requested to report. No formal report was prepared, Mr. White informed the Association, since due to the lack of entries there was no student dairy products judging contest conducted this year.

A report of the Committee on Legal Standards for Butter was called for. Prof. M. Mortensen, Chairman. As the work of that Committee had formerly been completed only a brief report was presented. Report follows:

Legal Standards for Butter

The Committee on Legal Standards for Butter presented through the Chairman of the Committee the following report at the hearing before the Joint Committee on Definitions and Standards held at St. Paul, Minnesota, June 19, 1918.

The Committee on Standards appointed by the American Dairy Science Association respectfully submits the following recommendations for your consideration.

At a recent meeting of the American Dairy Science Association the subject of butter standards was under consideration and it was unanimously recommended that an 80 per cent butter fat standard be adopted instead of the present 16 per cent moisture standard.

The Committee furthermore wishes to recommend 82½ per cent butter fat standard for unsalted butter. This latter recommendation is made for the reason that several creameries are selling unsalted butter at a price ranging from one to two cents per pound above the price of salted butter. The manufacturers claim that they are losing the advantage of from two to three per cent salt. It therefore seems fair that we should have some such standard for unsalted butter as it would, in the opinion of this Committee, form a fairer basis for competition.

Respectfully yours,

(Signed) M. MORTENSEN, *Chairman*,
S. C. THOMPSON,
E. S. GUTHRIE
G. H. BENKENDORF,
H. H. KILDEE.

In accordance with the above recommendation your Committee considers that unsalted butter should be defined as butter containing less than seven-tenths of one per cent salt.

Dairy butter should be defined as butter made on the farm where the butter fat is produced and from a herd of not more than one hundred cows in milk. A person making butter from milk or cream from more than one herd is a purchaser of milk or cream for manufacturing purposes and should therefore comply with the requirements made for commercial manufacturers.

It is recommended by your Committee that a copy of this report, if adopted, be forwarded to the Joint Committee on Definitions and Standards, Bureau of Chemistry, Washington, D. C.

Discussion

Professor Bouska: Twenty to twenty-five years ago unsalted butter was demanded by the Jewish trade. The manufacturers were so particular in the manufacture of such butter that the churn was rinsed to get out any trace of salt and unsalted butter should be made the same today. Accordingly seven-tenths of a per cent of salt is too high.

Professor Hunziker spoke in opposition to the double standard or a separate standard for unsalted butter. Professor Bouska said that

merchants buying such butter at times submitted samples to chemists to be tested and it should be without salt.

Professor Frandsen moved that the report be received and placed on file and that the Committee continue this work. Motion seconded and carried.

Professor Reed suggested that there were too many inactive committees. Too many of our institutions are working on the same problems. This is true in reference to problems on production work. Mr. Reed furthermore suggested that the stations should coöperate. Thus the problems could be worked out in a shorter time and more efficient work could be done by each station when handling just one part of the problem.

Professor Potts considered that there should be a field for coöperative dairy work and suggested that a committee on coördination be created.

Professor Bouska thought that while the method of conducting the committees would induce efficiency another matter is to get the newer men working. If we can interest them then the association becomes stronger.

Professor Stocking informed the Association that in selecting the committees he selected many of the younger men.

Professor Frandsen considered Professor Reed's suggestion a timely one and well worth considering.

The meeting was adjourned until 6.30 p.m.

SECOND SESSION

Busy Bee Restaurant, 6.30 p.m.

After the banquet the meeting was called to order by President Stocking.

A report of the Committee on Methods of Conducting Student Dairy Cattle Judging Contest was called for. Mr. Rabild, Chairman. Report follows:

Methods of Conducting Student Dairy Cattle Judging Contest

Your committee on methods of conducting the Students' National Contest in Judging Dairy Cattle has been singularly fortunate this year in being able to get together for a conference. This was held in Chicago on July 18 and 19, and all the members of the committee were

in attendance. The committee consists of Professors H. H. Wing, H. H. Kildee, W. W. Swett, J. B. Fitch, E. L. Anthony, W. M. Regan, and Mr. Helmar Rabild.

At this meeting the rules of the contest were thoroughly discussed and it was decided to amend the rules in two particulars. One amendment referred to the rating which should be given for switching animals within close pairs and pairs far apart, and is as follows:

> The student shall be cut 10 points instead of 15 for transposing the animals within a close pair or pairs, and shall be cut 20 points instead of 15 for transposing animals in a far-apart pair or pairs. This rule ceases to apply just as soon as any animal is transposed more than one place from its correct placing. Thereafter the rule of 15 points deducted for each place the animal is transposed from the correct placing shall apply.

The second amendment refers to the number of classes which shall be judged, and provides for an additional class of young stock as follows:

> 1. Four animals shall constitute a class. In each breed there shall be one class of bulls, one class of cows, and another class of the same breed.
> 2. The cattle shall be known by cards (A, B, C, D) on the animal's attendants.
> 3. The third class shall consist preferably of heifers; but in case suitable animals cannot be secured, animals of a different age or sex may be substituted in their place. No reasons will be written on this class.

These amendments were incorporated in the rules for this year.

Some time before the holding of the present dairy show it became evident that the participation in the Students' National Contest in Judging Dairy Cattle this year would be very limited owing to the transfer of the male student body of the agricultural colleges to the military branch of the Government. We therefore suggested to the dairy show management the advisability of deciding upon the minimum number of teams which would warrant the holding of a contest. In our own opinion this should be fixed at five teams or 15 students.

On October 4 the dairy show management wired us that there were only three teams entered, one of which was entered conditionally, and two students from a fourth college. This telegram, however, did not arrive in Washington until October 8, and we at once sent a telegram advising the cancellation of the contest. The dairy show management wired back that one of the teams was already on its way to the show and it would now be too late for cancellation. I am frank to admit, therefore, that it is against my best judgment that this contest was held with so limited participation. This has involved numerous difficul-

ties, especially in the placing of the animals by the judging committee. It has, however, given us an opportunity to try out on a small scale the practicability of the addition of four new classes; namely, four classes of young stock.

This has had the effect of giving more weight to and placing of animals and less weight to the rating received on reasons, in that the student now gets three ranks on placings in each breed and only two ranks on written reasons.

With your permission, I will read the report of the contest just closed.

STUDENTS' NATIONAL CONTEST IN JUDGING DAIRY CATTLE

The tenth annual Students' National Contest in Judging Dairy Cattle was held at the National Dairy Show at Columbus, Ohio, October 11, 1918. The contest was open to teams of three men each from all agricultural colleges, but owing to the enrollment of practically all male students in the military forces of the Nation, only three colleges, Cornell, Ohio, and Nebraska, were able to send full teams of three students each. A fourth college, South Dakota, sent two men to compete as individuals. One of the noteworthy features was that Cornell University entered a woman student. This is the first time in the history of the contest that a woman has contested with the male students for the honors of the judging ring.

Twelve animals of each of four dairy breeds were judged; namely, four bulls, four cows and four heifers; and the students were required to place these animals in their proper order of excellence. Their placing was then compared with the official contest placing, which was determined by a committee consisting of the coaches of the various teams. This committee was composed of Professors H. H. Wing, Cornell; C. T. Conklin, Ohio; Eli Duncombe, Nebraska; and Robert Wylie, South Dakota.

Iowa Dairy Separator Scholarship ($400)

The Iowa Dairy Separator scholarship, offered by the Associated Manufacturers Company of Waterloo, Iowa, was won by the University of Nebraska, whose team stood highest in judging all breeds.

DeLaval Scholarship ($400)

The DeLaval Scholarship, offered by the DeLaval Separator Company, was won by M. W. Lawritson of the University of Nebraska, for doing the best work in judging all the breeds.

Holstein-Friesian Scholarship

The Holstein-Friesian scholarship, offered by the Holstein-Friesian Association of America, to the student standing highest in the judging of Holstein, was won by Elizabeth R. Cook of Cornell University.

Standing of Teams

	Score
Sweepstakes teams:	
University of Nebraska	42
N. Y. State College of Agriculture	54
Ohio State University	75
Ayrshire:	
University of Nebraska	7
Ohio State University	14
New York State College of Agriculture	23
Guernsey:	
New York State College of Agriculture	10
University of Nebraska	10
Ohio State University	22
Holstein:	
New York State College of Agriculture	9
University of Nebraska	12
Ohio State University	21
Jersey:	
New York State College of Agriculture	12
University of Nebraska	13
Ohio State University	18

This resulted in the following awards:

Hoard's Dairyman's Cup	Won by the University of Nebraska
National Dairy Association Cup	Won by the University of Nebraska
J. B. Ford Cup	Won by New York State College of Agriculture
Ayrshire Cup	Won by University of Nebraska
Guernsey Cup	Won by New York State College of Agriculture
Holstein Cup	Won by New York State College of Agriculture
Jersey Cup	Won by New York State College of Agriculture

National Dairy Association Medals

The National Dairy Association awarded gold medals to the five highest, of sweepstakes, winners in judging all breeds, as follows:

1. M. W. Lawritson	Nebraska
2. Carl H. Powell	Nebraska
3. Lowell S. Hungington	New York
4. Daniel J. Carey	New York
5. Elizabeth R. Cook	New York

Motion made, seconded, and carried that the report be accepted and placed on record.

The Secretary's Report was called for. Report follows:

Secretary's Report

We have during the past year obtained seventeen new members for the Association. Of the old members, three have requested to be dropped, nineteen were dropped for non-payment of dues, leaving the Association at present one hundred and seventy members, of whom one hundred and sixty have paid their dues up to date.

Motion made, seconded, and carried that the report be accepted and placed on record.

The Treasurer's Report was called for. Report follows:

Motion made by Professor Lockwood that the editor-in-chief be allowed to draw on the treasurer for an amount not to exceed $100 for the coming year. Motion seconded and carried.

The following members were nominated as officers for the coming year:

President, Prof. A. C. Anderson, East Lansing, Mich.

Vice-President, Prof. M. Mortensen, Ames, Iowa.

Secretary-Treasurer, Prof. N. W. Hepburn, Urbana, Ill.

Moved by Professor Lockwood, seconded and carried that the secretary be instructed to cast a unanimous ballot electing the officers as nominated.

Moved by Professor Lockwood that a letter of appreciation be mailed to all members now engaged in military service, extending greetings from the Association. Seconded by Rabild and carried.

Professor Frandsen was called upon for remarks. He suggested that a resolution committee be appointed to draw up resolutions commending the work of Mr. Potts. Moved by Professor Reed that such a committee be appointed. This committee consisted of C. W. Larsen, J. H. Frandsen, N. W. Hepburn.

Moved by Professor Reed that it is the opinion of the American Dairy Science Association that we commend the work of the Bureau of Markets and that this work be continued. Motion seconded and carried.

Report of the Committee on Resolutions follows:

The American Dairy Science Association, whose membership is composed primarily of the educational, investigational and extension forces of agricultural colleges and other dairy institutions, and which has for

its purpose the advancement of dairy science and the dairy industry, at its Annual Conference held in Columbus, Ohio, on October 14, 1918, adopted the following resolution:

WHEREAS, the Department of Agriculture, through the Bureau of Markets, is able to render, and has rendered, most useful and valuable service to those engaged in the production, manufacture, marketing and distribution of dairy products through the compiling and issuing of dairy market reports containing accurate and reliable information in regard to the production, supply, demand, prices, and market conditions of dairy products; and,

WHEREAS, this service is at present conducted on a temporary basis under a war emergency Act of Congress; and,

WHEREAS, such service is equally as important, useful and valuable in times of peace as in time of war, and any curtailment of this service at the close of the war would be of great loss to the dairy industry and would greatly handicap the conduct and development of the industry, therefore

BE IT RESOLVED, that this Association express its sincere appreciation and commendation of the work already undertaken and petition the Secretary of Agriculture, Hon. David F. Houston, to use his good offices in securing the establishment of this work as a regular and permanent feature of the dairy marketing work of the Bureau of Markets, of the Department of Agriculture, which, to producers, distributers and consumers of dairy products, has proven to be extremely useful and valuable.

Director C. G. Woodbury of Indiana was called upon for a few remarks. He was interested in considering the subject of how the dairy school could be of greatest service to our nation. He considered that there are many subjects on dairy production and management which might be taken up jointly by different stations. A problem might be divided up between four or five different states, each state handling its problem. Such a plan would be feasible and practical if the men engaged in the work are big enough. Small men cannot coöperate. Men who can coöperate are such as take greater interest in service than in their own interests.

The retiring president was called upon for a few remarks after which the meeting adjourned.

(Signed)
M. MORTENSEN,
Secretary-Treasurer.

THE SAMPLING OF FRESHLY DRAWN MILK FOR COW-TESTING ASSOCIATION WORK[1]

R. H. SHAW AND E. F. DEYSHER

Research Laboratories, Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, Washington

In cow-testing association work time is an important factor. The number of cows which the operator is called upon to test on any one farm frequently taxes his capacity to the limit.

To conserve his time and permit him to perform the maximum number of tests, it is important for him to eliminate all unnecessary steps and do only those that are necessary for obtaining accurate results. The vast amount of work that has been done on the Babcock test itself leaves little to be desired in that direction. To obtain accurate results with the Babcock test, however, a representative sample must be used. No matter how nearly perfect the test, if the sample was not truly representative, it is worse than useless. Proper sampling, then, is in some respects the most important part of milk testing. The operator can judge by the appearance of the fat column whether or not he has made a good test. He has no visible way of knowing whether or not his sample is representative.

At the request of Mr. Helmer Rabild of the Dairy Division, an investigation was undertaken to study some of the factors involved in the taking of milk samples under cow-testing association conditions. The investigation which is herewith reported covers the following points: (1) Error in measured sample taken directly from freshly drawn milk; (2) the use of the milk thief with the shot-gun can; (3) errors introduced in taking equal samples of night and morning milk, instead of aliquot or proportionate samples to make up the composite; and (4) variations in the fat percentage due to the number of pourings or mixings.

[1] Published by permission of the Secretary of Agriculture.

Error in measured samples taken directly from freshly drawn milk. Milk as it leaves the animal has, of course, the body temperature. This is about 34° F., higher than the temperature at which the pipette is calibrated. The milk pipette is usually calibrated to deliver 17.5 cc. of milk which will average to weigh 18 grams at 68°, consequently it will deliver considerably less than 18 grams if the milk is at the body temperature. Freshly drawn milk is charged with gas, consequently the charge delivered by the pipette will not consist of milk alone but a mixture of milk and gas. Moreover the gas in escaping produces foam in the neck of the pipette so that if the operator reads the apparent milk line he is really reading a point considerably too high. These errors are all minus ones, i.e., they all tend to make the percentage of fat appear less than it really is. The sum of these errors may be very considerable and certainly enough to discount tests made in this way.

The use of the milk thief with shot-gun can. The bore of the milk thief submitted as a sample of those generally used in cow-testing work was 0.4 inch. By applying the formula for the volume of cylinders ($\pi r^2 \times h$) it is shown that for each inch the thief is submerged about 2 cc. (exactly 2.05 cc.) will theoretically be withdrawn.

The available shot-gun cans averaged about 8.5 inches in inside diameter. Applying the formula for the volume of cylinders and taking 1.032 as the average specific gravity, it is shown that 1 pound of average milk fills the shot-gun can to a depth of 0.472 inch. In other words, it requires 2.12 pounds of such milk to fill the can to a depth of 1 inch; consequently, the thief will theoretically remove 2.05 cc. for each 2.12 pounds, or approximately 1 cc. per pound.

If the operator runs his tests in duplicate, he will theoretically require (2 × 17.6) 35.2 cc. milk. If he does not make his tests in duplicate, he will need enough of the sample for a repeater in case he loses the test. In either case, a quantity of milk sufficient for two tests will be required. He will actually need not less than 40 cc. One thiefful will, therefore, not be sufficient in either case, since the depth required for enough

milk to deliver this amount (41.34 pounds) will tax the capacity of the can. The number of times the thief must be submerged for any definite number of pounds to withdraw 40 cc., can readily be found in table 1.

Rate at which thief should be lowered. A thief having about the same bore and orifice as the standard thief was made of glass and by its means in connection with a glass cylinder it was possible to observe the rate at which the milk rose inside the tube. It was found that if the thief was lowered at a rate not exceeding its whole length in two seconds, or while one is counting eight, that the same level inside as outside was main-

TABLE 1

Showing the number of pounds of milk in the standard diameter shotgun can for any given depth

DEPTH	MILK	DEPTH	MILK
inches	*pounds*	*inches*	*pounds*
1	2.12	10	21.20
2	4.24	11	23.32
3	6.36	12	25.44
4	8.48	13	27.56
5	10.60	14	29.68
6	12.72	15	31.80
7	14.84	16	33.92
8	16.96	17	36.04
9	19.08		

tained. For a lesser depth of milk a correspondingly shorter interval is, of course, required.

Errors introduced in sampling; if, instead of taking aliquot samples of night and morning milk equal samples are taken to make up the composite. To solve this problem it is only necessary to obtain reliable reports of tests where both night and morning milk was weighed and tested for fat. Some hypothetical cases may first be considered. Assume that a cow, say a Holstein, yields 40 pounds of milk per day, 18 pounds in the morning testing 3.5 per cent and 22 pounds in the evening testing 3.2 per cent. From the figures the amount of fat yielded in the

morning was 0.63 pounds and in the evening 0.704, totaling 1.334 pounds, then

$$\frac{1.334 \times 100}{40} \text{ or } 3.335 \text{ per cent}$$

is the correct percentage (average) as would be given by a composite made up of aliquots, and

$$\frac{3.5 + 3.2}{2} \text{ or } 3.35 \text{ per cent}$$

would be the test if the composite was made up of equal parts of morning and night milk. This would account for an error of a +0.015 per cent.

Again let it be assumed that the cow yields 18 pounds in the morning testing 3.8 per cent and 22 pounds in the evening testing 2.8 per cent. An error of +0.05 per cent would result. If she gave 16 pounds in the morning testing 3.8 per cent and 24 pounds in the evening testing 3 per cent, an error of +0.08 per cent would be made. If, in this last case, the larger quantity of milk had tested the highest and the smaller quantity the lowest, an error of −0.08 per cent would have occurred.

Now to consider a richer grade of milk we may select a hypothetical Jersey cow giving 20 pounds of milk per day, 8 pounds in the morning testing 5 per cent and 12 pounds in the evening testing 4.5 per cent. The error would be +0.05 per cent. If she gave 8 pounds in the morning testing 6 per cent and 12 pounds in the evening testing 5 per cent, the error would be +0.10 per cent. If she gave 7 pounds in the morning testing 6 per cent and 13 pounds in the evening testing 5 per cent, the error would be +0.15 per cent.

The above examples are all hypothetical. We will now consider some real ones: The records of some official tests of Guernsey cows at the Dairy Division Farm at Beltsville, Maryland were available. These cows were milked twice daily with a fairly uniform interval of time between milkings. Through the courtesy of the manager of the dairy at Soldiers' Home in Washington, access was allowed to the records of the

official tests of some Holstein cows. These cows were milked three times daily. It is not believed, however, that this fact will detract from the value of the figures in illustrating the errors. In selecting the figures only two milkings per day were considered, the third being ignored. The figures showing milk yield, test and error are given below in tabular form. The errors were calculated in the same way as in the hypothetical cases. To supplement these figures a table is included showing the results obtained from consecutive milkings of the cows used in the investigation reported later in this paper.

TABLE 2

Showing errors due to using equal instead of aliquot parts in making composite samples (Guernsey cows)

NUMBER OF COW	A.M. MILKING		P.M. MILKING		ERROR
	Milk	Fat	Milk	Fat	
	pounds	*per cent*	*pounds*	*per cent*	
1	6.4	4.8	4.1	5.7	+0.10
1	5.3	4.9	4.3	5.6	+0.04
1	7.0	4.9	5.6	4.75	None
1	6.8	5.15	5.6	5.3	+0.008
1	7.2	5.2	5.9	5.0	−0.01
1	7.7	4.8	6.4	5.2	+0.02
2	5.0	6.1	3.7	6.0	−0.01
2	4.8	6.2	4.2	5.4	−0.03
3	7.0	5.2	5.6	5.3	+0.01
3	6.2	5.4	8.3	5.8	None
4	8.7	5.4	8.3	5.8	None
4	8.0	6.1	7.6	6.0	None

EXPERIMENTAL

The following part of the work was done at the Dairy Division Experimental Farm at Beltsville. A twenty-four bottle steam tester was used. The test bottles were of the 8 per cent type and all had been passed by the United States Bureau of Standards. The mixing and sampling were done right at the barn and under conditions similar to those met by the cow tester.

TABLE 3

Showing errors in using equal instead of aliquot parts in making composite samples (Holstein cows)

NUMBER OF COW	FIRST MILKING		SECOND MILKING		ERROR
	Milk	Fat	Milk	Fat	
	pounds	*per cent*	*pounds*	*per cent*	
1	18.2	3.4	16.2	3.8	+0.012
1	17.3	3.2	15.5	3.8	+0.016
1	15.8	3.4	14.1	3.8	+0.02
2	18.5	3.6	16.9	3.6	+0.01
2	17.9	3.0	16.3	3.8	+0.02
2	17.5	2.8	17.1	3.2	+0.003
3	31.0	3.8	33.1	3.0	+0.02
3	30.6	3.0	30.5	3.3	+0.001
3	32.7	3.2	32.5	4.0	+0.002
4	20.7	2.6	21.5	3.9	−0.01
4	23.6	3.6	19.5	4.0	+0.04
4	24.9	3.5	20.0	4.6	+0.07
5	29.6	3.5	28.5	3.2	None
5	31.0	2.5	26.5	3.0	+0.02
6	25.6	2.5	23.5	3.2	+0.02
6	25.0	2.9	21.8	3.6	+0.025
6	26.9	2.7	24.0	3.4	+0.02
7	16.4	2.8	16.2	3.2	+0.01
7	16.5	3.2	16.5	3.1	None
7	16.1	3.8	13.6	3.0	−0.03
8	25.7	3.0	21.0	3.2	+0.02

TABLE 4

Showing errors due to using equal instead of aliquot parts in making composite samples (cows used in investigation described later in paper)

NUMBER OF COW	FIRST MILKING		SECOND MILKING		ERROR
	Milk	Fat	Milk	Fat	
	pounds	*per cent*	*pounds*	*per cent*	
51	8.5	3.47	8.2	3.42	None
51	8.2	3.42	6.5	3.42	None
51	6.5	3.42	8.8	3.59	−0.01
51	8.8	3.59	5.6	3.46	+0.06
211	10.9	3.62	8.2	2.71	−0.06
211	8.2	2.71	11.0	3.15	−0.03
211	11.0	3.15	15.1	2.71	None
211	15.1	2.71	11.2	3.06	−0.01
39	9.4	3.32	7.1	4.87	+0.10
39	7.1	4.87	10.0	3.88	+0.08
39	10.0	3.88	7.2	5.20	+0.11
218	13.5	4.03	18.0	2.64	+0.10
219	12.5	3.04	14.2	2.50	−0.02

Sampling. As the milk was received from the milker, a sample of about 50 cc. was taken from the upper part with a small dipper and at the same time a sample withdrawn with a milk thief. The milk was then poured into a shot-gun can, this operation constituting the "one pouring" noted in the tables, and samples again taken. This was repeated up to five pourings, except that in some cases samples were not taken from the fourth pouring. The experiments were conducted on both night and morning milk. The tests were all made in duplicate and the readings between the marks interpolated as closely as possible. The average figures are shown in the following tables.

Table 5 showing the variation in percentage fat due to the pourings is self-explanatory. Table 6 is prepared from table 5 and shows the deviation in percentage of fat in the samples from the different pourings from the figure secured by averaging the percentage obtained from all the milk thief-samples.

If the tester removes his samples with a dipper from the top layer of the milk, the question immediately arises as to how soon must he remove them before enough fat globules have arisen to make that layer appreciably higher in fat than the lower layers of the milk.

To answer this question milk from both Guernsey and Holstein cows was used. The milk was first mixed by pouring from one pail into another and sampled. It was then allowed to stand for various intervals of from one to thirty-five minutes, samples being taken after each interval. The results are given in tables 7 and 8.

DISCUSSION

The average milk test bottle is not perfect. Its reliability depends upon the accuracy with which it is calibrated. The calibrations of milk bottles vary in accuracy and an error of 0.1 per cent is allowed by the U. S. Bureau of Standards. The most careful work with the Babcock test, therefore unless done in duplicate or triplicate, will give results that may be in error of 1 ± 0.1 per cent due to the test bottles

TABLE 5*

Showing variation in percentage fat due to the number of pourings

		cow 51	cow 51	cow 51	cow 51	cow 51	cow 51	cow 110	cow 110	cow 110
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
No pouring	dipper	4.79	3.50	3.34	3.45	3.67	3.50	6.89	5.48	7.47
	thief	4.69	3.48	3.40	3.43	3.56	3.50	6.99	5.48	7.50
First pouring	dipper	4.72	3.44	3.37	3.46	3.52	3.40	6.94	5.49	7.53
	thief	4.77	3.45	3.40	3.45	3.60	3.50	6.95	5.48	7.50
Second pouring	dipper	4.79	3.47	3.40	3.43	3.59	3.33	6.97	5.52	7.50
	thief	4.79	3.48	3.44	3.44	3.61	3.31	6.95	5.49	7.50
Third pouring	dipper	4.74	3.46	3.50	3.44	3.59	3.48	6.90	5.49	7.53
	thief	4.74	3.48	3.45	3.38	3.60	3.49	6.95	5.48	7.56
Fourth pouring	dipper	4.72	3.48	3.44	3.44			6.90	5.50	7.52
	thief	4.70	3.47	3.41	3.41			6.93	5.50	7.55
Fifth pouring	dipper	4.76	3.43	3.50	3.43	3.54	3.50	6.94	5.50	7.50
	thief	4.75	3.46	3.40	3.43	3.57	3.48		5.49	
Average	dipper	4.75	3.46	3.43	3.44	3.58	3.44	6.92	5.50	7.51
	thief	4.74	3.47	3.42	3.42	3.59	3.46	6.95	5.49	7.52
Average of all determinations		4.75	3.47	3.42	3.43	3.59	3.45	6.94	5.49	7.51
Yield (pounds)		13.2	8.5	8.2	6.5	8.8	5.6	10.2	6.3	4.9
Time (minutes)		5	5	4	3¾	4	4	4½	4½	4½

		cow 208	cow 208	cow 208	cow 211	cow 211	cow 211	cow 211	cow 211
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
No pouring	dipper...	3.55		3.19	3.67	2.80	3.13	2.77	3.09
	thief.....	3.42		3.17	3.61	2.75	3.19	2.73	3.14
First pouring	dipper...	3.46	3.55	3.15	3.59	2.63	3.14	2.69	3.08
	thief.....	3.44	3.55	3.18	3.62	2.72	3.19	2.70	3.15
Second pouring	dipper...	3.52	3.51	3.12	3.63	2.71	3.22	2.63	3.04
	thief.....	3.50	3.51	3.16	3.58	2.68	3.18	2.73	3.09
Third pouring	dipper...	3.46	3.50	3.19	3.61	2.69	3.14	2.70	3.06
	thief.....	3.47	3.54	3.19	3.60	2.68	3.17	2.74	3.06

* In tables 4 and 5, each column represents a milking. Cows 208, 211, 218 and 219 are Holsteins. Cow 51 is a grade Holstein. Cow 110 is a Guernsey. Cow 39 is a grade Guernsey.

TABLE 5—*Continued*

		cow 208	cow 208	cow 208	cow 211	cow 211	cow 211	cow 211	cow 211
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Fourth pouring	dipper...	3.50	3.50	3.19	3.60	2.72	3.11		
	thief.....	3.46	3.54	3.20	3.61	2.71	3.16		
Fifth pouring	dipper...	3.49	3.54	3.18	3.60	2.71	3.17	2.77	3.03
	thief.....	3.52	3.53	3.19	3.61	2.77	3.14	2.73	3.05
Average	dipper...	3.50	3.52	3.17	3.62	2.71	3.15	2.71	3.06
	thief.....	3.47	3.53	3.18	3.61	2.72	3.17	2.73	3.10
Average of all determinations.....		3.48	3.53	3.18	3.61	2.71	3.16	2.72	3.08
Yield (pounds).....		11.7	11.3	6.8	10.9	8.2	11.0	15.1	11.2
Time (minutes).....		5	4	4½		5½	4	5½	5¼

		cow 39	cow 39	cow 39	cow 39	cow 218	cow 218	cow 219	cow 219
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
No pouring	dipper...	3.36	4.91	4.02	5.20	4.02	2.69	3.08	2.50
	thief.....	3.30	4.87	3.91	5.17	4.04	2.59	3.08	2.50
First pouring	dipper...	3.29	4.89	3.88	5.19	3.98	2.61	3.05	2.46
	thief.....	3.34	4.84	3.91	5.19	4.04	2.66	3.03	2.49
Second pouring	dipper...	3.34	4.90	3.85	5.21	4.03	2.65	3.07	2.46
	thief.....	3.37	4.96	3.86	5.23	4.02	2.65	3.01	2.50
Third pouring	dipper...	3.32	4.87	3.89	5.20	4.00	2.64	3.01	2.49
	thief.....	3.31	4.89	3.89	5.20	4.02	2.65	3.03	2.49
Fourth pouring	dipper...	3.35	4.89						
	thief.....	3.20	4.82						
Fifth pouring	dipper...	3.26	4.81	3.82	5.19	4.01	2.64	3.02	2.48
	thief.....	3.31	4.85	3.84	5.22	4.02	2.64	3.03	2.51
Average	dipper...	3.32	4.88	3.89	5.20	4.01	2.65	3.05	2.48
	thief.....	3.31	4.87	3.88	5.20	4.03	2.64	3.04	2.50
Average of all determinations.....		3.31	4.88	3.89	5.20	4.02	2.64	3.04	2.49
Yield (pounds).....		9.4	7.1	10.0	7.2	13.5	18	12.5	14.2
Time (minutes).....		9	4	9¾	7	7¾	10	7	9

TABLE 6

Showing the deviation in percentage of fat in the samples from the different pourings from the average percentage

		cow 51	cow 51	cow 51	cow 51	cow 51	cow 51	cow 110	cow 110	cow 110
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Average		4.74	3.47	3.42	3.42	3.59	3.46	6.95	5.49	7.52
No pouring	dipper	+0.05	+0.03	−0.08	+0.03	+0.08	+0.04	−0.06	−0.01	−0.05
	thief	−0.05	+0.01	−0.02	+0.01	−0.03	+0.04	+0.04	−0.01	−0.02
First pouring	dipper	−0.02	−0.03	−0.05	+0.04	−0.07	−0.06	−0.01	0.00	+0.01
	thief	+0.03	−0.02	−0.02	+0.03	+0.01	+0.04	0.00	−0.01	+0.02
Second pouring	dipper	+0.05	0.00	−0.02	+0.01	0.00	−0.13	+0.02	+0.03	−0.02
	thief	+0.05	+0.01	+0.02	+0.02	+0.02	−0.15	0.00	0.00	−0.02
Third pouring	dipper	0.00	−0.01	+0.08	+0.02	0.00	+0.02	−0.05	0.00	+0.01
	thief	0.00	+0.01	+0.03	−0.04	+0.01	+0.03	0.00	−0.01	+0.04
Fourth pouring	dipper	−0.02	+0.01	+0.02	+0.02			−0.05	+0.01	0.00
	thief	−0.04	0.00	−0.01	−0.01			−0.02	+0.01	+0.03
Fifth pouring	dipper	+0.02	−0.04	+0.08	+0.01	−0.05	+0.04	−0.01	+0.01	−0.02
	thief	+0.01	−0.01	−0.02	+0.01	−0.02	+0.02		0.00	

		cow 208	cow 208	cow 208	cow 211	cow 211	cow 211	cow 211	cow 211
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Average		3.47	3.53	3.18	3.61	2.72	3.17	2.73	3.10
No pouring	dipper	+0.08		+0.01	+0.06	+0.08	−0.04	+0.04	−0.01
	thief	−0.05		−0.01	0.00	+0.03	+0.02	0.00	+0.04
First pouring	dipper	−0.01	+0.02	−0.03	−0.02	−0.09	−0.03	−0.04	−0.02
	thief	−0.03	+0.02	0.00	+0.01	0.00	+0.02	−0.03	+0.05
Second pouring	dipper	+0.05	−0.02	−0.06	+0.02	−0.01	+0.05	−0.10	−0.06
	thief	+0.03	−0.02	−0.02	−0.03	−0.04	+0.01	0.00	−0.01
Third pouring	dipper	−0.01	−0.03	+0.01	0.00	−0.03	−0.03	−0.03	−0.04
	thief	0.00	+0.01	+0.01	−0.01	−0.04	0.00	+0.01	−0.04
Fourth pouring	dipper	+0.03	−0.03	+0.01	−0.01	0.00	−0.06		
	thief	−0.01	+0.01	+0.02	0.00	−0.01	−0.01		
Fifth pouring	dipper	+0.02	+0.01	0.00	−0.01	−0.01	0.00	+0.04	−0.07
	thief	+0.05	0.00	+0.01	0.00	+0.05	−0.03	0.00	−0.05

TABLE 6—*Concluded.*

		cow 39	cow 39	cow 39	cow 39	cow 218	cow 218	cow 219	cow 219
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Average		3.31	4.87	3.88	5.20	4.03	2.64	3.04	2.50
No pouring	dipper	+0.05	+0.04	+0.14	0.00	−0.01	+0.05	+0.04	0.00
	thief	+0.01	0.00	+0.03	−0.03	+0.01	−0.05	+0.04	0.00
First pouring	dipper	−0.02	+0.02	0.00	−0.01	−0.05	−0.03	+0.01	−0.04
	thief	+0.03	−0.03	+0.03	−0.01	+0.01	+0.02	−0.01	−0.01
Second pouring	dipper	+0.03	+0.03	−0.03	+0.01	0.00	+0.01	+0.03	−0.04
	thief	+0.06	+0.11	−0.02	+0.03	−0.01	+0.01	−0.03	0.00
Third pouring	dipper	+0.01	0.00	+0.01	0.00	−0.03	0.00	−0.03	−0.01
	thief	0.00	+0.02	+0.01	0.00	−0.01	+0.01	−0.01	−0.01
Fourth pouring	dipper	+0.04	+0.02						
	thief	−0.11	−0.05						
Fifth pouring	dipper	−0.05	−0.06	−0.06	−0.01	−0.02	0.00	−0.02	−0.02
	thief	0.00	−0.02	−0.04	+0.02	−0.01	0.00	−0.01	+0.01

TABLE 7

Showing rise of fat in freshly drawn milk on standing

	GUERNSEY MILK NO. 1	GUERNSEY MILK NO. 2	GUERNSEY MILK NO. 3	GUERNSEY MILK NO. 4	HOLSTEIN MILK NO. 1	HOLSTEIN MILK NO. 2
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Fat before standing	6.49	5.70	6.88	5.40	3.29	2.87
Fat after standing 1 minute	6.50	5.70	6.86	5.42	3.25	2.88
Fat after standing 3 minutes	6.50	5.80	6.86	5.48	3.22	2.89
Fat after standing 5 minutes	6.50	5.80	7.02	5.50	3.24	2.89
Fat after standing 10 minutes	6.49	5.79	7.01	5.45	3.27	2.88
Fat after standing 25 minutes		6.03	7.14	5.67		

TABLE 8

Showing rise of fat in freshly drawn milk on standing

	HOLSTEIN MILK NO. 3	HOLSTEIN MILK NO. 4
	per cent	*per cent*
Fat before standing	3.36	2.85
Fat after standing 5 minutes	3.38	2.89
Fat after standing 10 minutes	3.43	2.86
Fat after standing 15 minutes	3.44	2.89
Fat after standing 25 minutes	3.42	2.86
Fat after standing 35 minutes	3.39	2.88

alone. This error with untested bottles may be even larger. In cow-testing work it is the exception rather than the rule to make tests in duplicate. The amount of work the average cow tester is called upon to do does not permit him to run more than one test for a sample; consequently no matter how nearly correct his manipulation the results may be ±0.1 per cent in error from conditions entirely out of his control.

The errors introduced by taking equal parts of consecutive milkings instead of aliquot or proportional parts in the figures available range from zero to 0.11 per cent as will be seen in tables 2, 3, and 4. These errors are in both directions, i.e., they are both plus and minus errors. If all the errors in the cases given are averaged it will be found that there remains an average error of only +0.016 per cent. In some abnormal cases as when the milk yield is greatly increased without a corresponding decrease in the percentage of fat or where the yield is greatly diminished without a corresponding increase in fat the error might be very considerable. With the average cow under normal conditions as found in cow-testing work it is not probable that the errors thus introduced are important, especially since in a series of tests covering a year they would tend to counterbalance. Moreover a sudden change in milk yield would be known at once by the tester and his sampling governed accordingly.

An inspection of tables 5 and 6 reveals a rather surprising agreement between the average test of the milk and the test of the different samples removed with a dipper directly from the milk as received from the milker. In no case did the figures disagree as much as 0.1 of 1 per cent. It would seem from the results that a fairly true representative sample can be obtained directly from the freshly drawn milk.

There is a fact, however, that should be considered in this connection and that is, the speed of milker. The men who drew the milk for this experiment were rapid milkers, and it is very probable that the milk in the pail was kept in a more agitated condition than if they had worked more slowly. The average milker on the farm is probably a slower operator,

and in consequence the milk will not be so thoroughly mixed. The figures indicate that one pouring may be safely depended upon to supply a sample fulfilling all the conditions of cow-testing work. This fits very well into the cow tester's procedure, for all he must do is to pour the milk, as he receives it from the milker, into the shot-gun can, take the weight and remove a sample with a dipper.

The use of the milk thief was time-consuming. In the case of cows giving a small amount of milk, as the Guernseys, it was sometimes necessary to insert it as many as ten times in order to obtain a quantity of milk sufficient for two tests; moreover, the results show no advantage in its use for sampling freshly drawn milk.

The results given in table 6 would indicate that there need be no special hurry in sampling milk of low fat content as Holstein milk, since in thirty-five minutes the upper layer showed no appreciable gain in fat. This does not hold for high fat milk, however, since the upper layer of Guernsey milk showed a gain in four or five minutes.

SUMMARY AND CONCLUSION

The results of the experiment show that the use of the milk thief is time-consuming and unnecessary and in sampling freshly drawn milk.

The error introduced by taking equal instead of aliquot parts of the morning's and night's milk to make up the composite sample is probably too small to be of consequence in cow-testing work.

A representative sample may be obtained from freshly drawn milk by simply pouring it once, i.e., from the milking pail into the shot-gun can.

Freshly drawn low fat milk may stand for a half-hour before the upper layer has appreciably increased in fat. High fat milk must be sampled immediately. The results show that five minutes are sufficient for the fat in the upper layer to increase very perceptibly.

INHERITANCE OF JERSEY COLORS

J. J. HOOPER

University of Kentucky, Lexington, Kentucky

During the past seven years I have had charge of the Jersey herd at the Kentucky Experiment Station, where Prof. M. A. Scovell left it at the time of his death in 1912. That Dr. Scovell had established a most excellent herd is well known to all persons interested in Jersey cattle. During the past several years I have made a close study of the inheritance of coat, tongue and switch colors among our calves, to see how the colors are passed from parents to offspring. As calves are often produced in our herd that are broken in color, that come from solid colored ancestry for generations, I begun to wonder if broken color is a recessive characteristic, that may be carried without appearing for generations, submerged by the dominant characteristic—solid color. If it behaves as a recessive, then when two recessives are mated together (a broken colored bull and cow), a broken colored calf should result.

To study the matter fully, I consulted the Registry books of the American Jersey Cattle Club, and tabulated the color markings of 1145 calves, and of their 2290 sires and dams. As the study progressed I found that the mating together of broken colored ancestors produced a very large proportion of broken colored calves. Out of 209 matings of broken colored bulls on broken colored cows, 194 broken colored calves were produced, and 15 solid colored ones. Out of the 15 exceptions, 7 of them had a white or mottled tongue, or white or mixed switch. I have wondered if some or all of the fifteen calves did not actually carry white markings that may have developed after the calf was registered, as of solid color. We find it best to wait until the calf is several weeks old to register its color markings, because it frequently develops white that was not noticeable at birth. I next tabulated 436 matings of broken colored bulls on solid colored cows and found that 436 such matings produced 179 broken col-

ored calves and 257 solid colored ones. The next tabulation was the mating together of 500 solid colored bulls and cows, that produced 425 solid colored calves and 75 broken colored ones.

Certain sires we found to produce only solid colored calves, no matter what the color of the dam. One bull produced 88 solid colored calves, 84 from solid colored cows and 4 from broken colored cows. The nearest he ever came to producing a broken colored calf were 2 calves that had two small white spots on their body, and one of these that also had a white ring around the tail. Another bull that we studied produced 81 solid colored calves from 79 solid and 2 broken colored cows. Other bulls that we studied sired both broken and solid colored offspring. One produced, from 14 broken colored cows, 6 broken colored calves and 8 solid colored ones and from 58 solid colored cows, 14 broken colored calves and 14 solid colored ones. Thus it seems that some bulls (and cows, too) carry the solid coloring as a pure dominant, and their spermatozoa or ova will make the calf solid in color, even if it meets a germ from its mate that carries only a determiner for broken color. Most bulls and cows carry both solid and broken determiners and give them off alternately, thus producing calves of broken or solid coloring, dependent upon the germ from the other parent.

Let us now review briefly our work with broken colored parents. One broken colored bull that we studied sired 14 broken colored calves from 14 broken colored cows, and 17 broken colored calves and 16 solid colored calves from 33 solid colored cows. Apparently he is a pure recessive for broken color, for when mated with 14 broken colored cows (both bull and cow being incapable of giving off anything except broken colored determiners) this white spotted Jersey bull produced 14 broken colored calves.

The above discussion relates solely to body color, but we also studied the inheritance of tongue and switch, and found that white coloring is again apparently recessive.

In tabulating the color of Jersey cattle to learn definitely their precise color pattern, I tabulated the color markings of 1000 individuals. Sixty-six per cent of them I found to be solid and to

have black tongues and switches, 12 per cent are broken and have white tongues and switches. The other 22 per cent vary widely in their color pattern—3.6 per cent are solid and have white tongues and black switches, 2.5 per cent are broken colored but have black tongues and switches, etc.; 71 per cent of the broken colored Jerseys have white tongues, and 63 per cent have white switches. Out of 100 solid colored Jerseys, 89 will carry black tongues, and 91 will be found to have black switches.

We next studied the inheritance of tongue colors and found that a mating of white tongued parents produces 71 per cent white tongues calves. The mating of parents, both possessing white switches, produces 91 per cent white switches. The 9 per cent of mixed and black switches that we found from matings of white switched bulls and cows may be errors on the part of the people who registered the calves. It would be best to defer registering color until the calf has attained the age of two months or more.

Apparently the old roan Jersey color of years ago was dominant. We used to have roans on the Station farm, but after a time the roan dropped out and has not reappeared in our herd, and we find this holds true in many pedigrees tabulated of old Jerseys to study this point. When once lost it is apparently gone forever, like the roan and gray of horses.

THE COMPARATIVE VALUE OF QUANTITATIVE AND QUALITATIVE BACTERIOLOGICAL METHODS AS APPLIED TO MILK, WITH ESPECIAL CONSIDERATION OF THE METHYLENE BLUE REDUCTION TEST[1]

E. G. HASTINGS

Bacteriological Laboratory, University of Wisconsin, Madison

The value of bacteriological analyses in the dairy industry has been established beyond all question. From the viewpoints of the producer, the distributor, and the ultimate consumer of milk, whether the home or the dairy manufacturer, the bacteriological examination of milk gives information concerning the product that can be obtained in no other way. The further extension of such work is certain to be to the advantage of all concerned. It has seemed to the writer from experience gained during a considerable term of years, that a statement concerning the information which a bacteriological examination of milk can supply, and in regard to the comparative value of the various methods of determining the bacterial content of milk, would be of assistance to many whose chief interest lies in related fields, or to those whose experience in this field has been limited.

Roughly, the bacterial content of milk may be divided into two great classes, the specific, disease-producing organisms and the saprophytic organisms. An examination of milk for the presence of the tubercle or the typhoid organism is of little, if any, value in the control of milk supplies as far as safeguarding public health is concerned. The same is largely true as concerns the streptococci causing septic sore throat. Practically every sample of raw milk will contain streptococci, most of which are harmless. The differentiation of these harmless types from the harmful ones cannot be made with any degree

[1] Published with the permission of the Director of the Agricultural Experiment Station.

of certainty. Briefly, it may be said that in all routine examinations of milk the disease-producing organisms may be omitted from consideration and attention need be directed only to those saprophytic organisms which grow in the milk and which are thus the cause of the sequence of changes noted therein.

INFORMATION THE EXAMINATION SHOULD SUPPLY

The routine examination of milk should give the maximum amount of information concerning the number and kind of bacteria present in the sample examined. The bacterial content of any sample of milk depends on the number that has gained entrance to it from varied sources and on the extent to which those introduced have grown. The initial contamination of the milk, especially the contamination with dirt, manure, and soil from the animal, has been emphasized and attempts have been made to differentiate between this factor and the growth factor. Such a differentiation is theoretically desirable for it would reflect, to some extent, the methods used by the producer as regards cleanliness. The ability of the analyst to make such a differentiation would make his work directly comparable to farm inspection as far as information about the methods employed is concerned. In the past the equipment of the dairy farm has almost completely filled the inspector's vision, as well as that of those directing his work. It has taken a discouragingly long time for the majority of those concerned in such work to realize that *methods* rather than *equipment* are the points to be considered.

However desirable the differentiation between the bacterial cells bodily introduced into the milk and those resulting from growth of the introduced organisms, it must be admitted that little can be done along this line in ordinary routine analyses.

Such a differentiation as it is possible to make demands a skilled analyst and a more complete examination than is usually made in routine work. If the sample is known to be fresh, data of some value can be obtained, for in such milk the growth factor is largely absent. In older milk of high bacterial content the types of bacteria present may aid in telling something

of the initial contamination. If such a milk shows a variety of bacteria, it has been grossly contaminated, for, if such had not been the case, the lactic bacteria would have overgrown all others because of the more favorable conditions, especially in milk handled at the customary temperatures. It must be remembered, however, that contamination from utensils may involve any and all types of organisms that may have come originally from most varied sources. It is impossible to differentiate between such contamination and that due to the introduction of soil and manure, a differentiation that would be desirable if possible.

The analyst wishes to learn as much as possible concerning the past history of the samples of milk submitted to him, and furthermore, he is desirous of being able to indicate what their future history may be. Speaking in a general way, the interest is not limited to the particular sample under examination, but is extended to the source of the sample for from that source is likely to come tomorrow, or next week, or next month, milk of a similar quality, bacteriologically speaking. In other words, the laboratory examination should provide an index of how milk is being produced and handled on any particular farm or in any individual plant and an indication of its keeping quality. The methods used in the laboratory should be such as will give the most information with the least expenditure of time and money. Briefly, it may be said that bacteriological analyses are used by milk distributors and health officials to ascertain the quality of milk supplied by the individual producers; by milk distributors to determine the efficiency of operations in their plants; by health officials to determine the quality of milk supplied to the consumer. In this work both raw and pasteurized milk must be considered. A method may be of value under one set of conditions and may be of little value under other conditions.

METHODS AVAILABLE

Four methods for the determination of the number of bacteria in milk have been used to a greater or less extent. The methods are: first, the plate-culture method as recommended by the American Public Health Association and described in a pamphlet entitled "Standard Methods of Milk Analysis;" second, the Breed method or the direct microscopic count; third, the "little plate" method devised by Frost; fourth, the methylene blue reduction method. Each of these methods may give some idea of the types of bacteria present.

Plate culture method

The standard plate-culture method is so well known that no description need be given. The nutrient medium employed is a beef extract-peptone-agar containing no added carbohydrate. The omission of the latter makes the medium somewhat unfavorable for the development of the organisms belonging to the *Bact. lactis acidi* group and incidentally for streptococci, pathogenic or non-pathogenic. The medium was designed to determine the initial contamination from the animals, especially contamination with material containing *B. coli.* As pointed out above, the detection of the source of *B. coli* cannot be made.

The originators of the method seem to have had the idea that organisms of the *Bact. lactis acidi* group were of no importance. Indeed, there is a tendency among medical men to consider their presence in milk desirable. There is an element of truth in this idea, for, when lactic bacteria are present, they are likely to dominate the fermentative processes, since they grow comparatively well at the temperatures at which milk is handled. The chemical changes they produce in the milk do not render it objectionable for many culinary purposes. In the absence of lactic organisms, other forms of bacteria will find opportunity for growth and frequently the type of decomposition that occurs renders the milk totally unfit for use. The lactic organisms, however, are most important when the keeping quality

of the milk is considered. It would, therefore, seem desirable to use a nutrient medium in the plate culture method that should give the lactic organisms an opportunity for growth equal to that offered other less important groups of organisms. The addition of dextrose to the beef extract-peptone-agar now employed will make it approximate more closely the ideal medium, i.e., one that will permit the growth of all the kinds of bacteria that function in the spoiling of the milk. Dextrose is preferable to any other carbohydrate for it seems probable that any organism that can use any of the carbohydrates as a source of energy can use dextrose. Such a change in the medium will make it no less adapted to those organisms that do not require sugar, such as *B. coli*, in case plates are inoculated with proper amounts of the milk, or, in other words, providing some of the plates show such a number of colonies, that each colony grows uninfluenced by any other colony. If the qualitative aspect of the subject is to be considered, plate cultures with colonies ranging from fifty to two hundred are an absolute essential. Plates seeded with comparatively large amounts of milk may present the appearance of a pure culture of a lactic organism, while plates seeded with smaller amounts of the same milk may show a variety of forms.

When the plate culture method is applied to pasteurized milk it reveals little concerning the past history of the milk. It may tell something of its future.

There is no question concerning the value of the information that can be secured by this method when it is carried out in a careful manner by an experienced laboratory worker. As the work is usually done, the results show that there is at least a certain number of bacteria in the sample, but it is quite probable that the determined number is an extremely rough approximation to the actual number present. Breed has emphasized the fact that the plate method cannot determine the actual number of cells present. *Bact. lactis acidi* occurs largely in twos, therefore one would be safe in saying that the number of this group actually present in the amount of milk used in seeding the plate is probably almost twice as great as shown by the col-

onies. When it is realized that groups may contain tens and hundreds of cells, it will be seen that the plate method measures very roughly the bacterial content of the milk. It is probable that bacteria that are not detected by the plate method are constantly present in milk and are concerned in its decomposition. The work of Miss Evans on the group of organisms closely related to the abortion organism is evidence along this line.

An argument often advanced against the plate method is that it requires at least 48 hours before the results can be obtained. This is no valid objection to the method since, as has been pointed out, the idea is not to ascertain the bacterial content of the particular sample of milk for the purpose of determining its value, but rather to determine the general quality of milk coming from a certain source. Methods on a farm or in a milk plant do not change from good to bad or bad to good from day to day, but are uniformly good or bad and so the quality of the product is more or less uniform. The great disadvantage of the plate culture method is in the expensive equipment demanded and in the amount of time required of trained workers. It may well be questioned whether results of equal or greater value cannot be secured at far less expense by one of the other methods.

Direct microscopic method

The direct microscopic examination has the advantage of rapidity and of cheapness. It seems destined to play an important rôle in milk control. As with the plate culture method confidence in results obtained comes to the careful and conscientious worker only after considerable experience. Certain sources of error are inherent in the method. Unless the staining is done with care and judgment, bacteria may be hidden in the casein and probably certain groups of bacteria may be missed entirely. It is doubtful whether such small organisms as those of the *B. abortus* group would be detected, especially when they do not stain easily with methylene blue. Another argument that has been urged against the method is that it cannot be applied with success to milks of low bacterial content. With the usual microscopic

equipment employed each organism in the field of the microscope signifies 500,000 in each cubic centimeter of milk. If, on the average, but one organism can be found in ten fields, it certainly means that the bacterial content is low and approximates 50,000 per cubic centimeter.

Milk control demands and needs only approximate results and such results the direct microscopic method is able to furnish with little expense. A glance at a few fields of a well prepared slide will enable the experienced worker to judge the bacterial content of the sample with all the accuracy necessary in control work.

It does not seem probable that the direct microscopic method will supply as much information concerning the kinds of organisms present as will the plate culture method. Every bacteriologist recognizes that cultures are of more value in identifying bacteria than microscopic preparations. In the detection of streptococci it may be that the direct microscopic examination has the advantage over the plate culture method.

The value of the method when applied to pasteurized milk is somewhat questionable. It seems probable that soon after pasteurization the dead cells stain, but that their staining properties are gradually lost. Under these conditions the direct microscopic method would furnish questionable results as far as the past history of the milk is concerned.

A promising development of the direct microscopic method is in its application to composite samples of milk. As has been stated, the value of any examination is in furnishing an index of the quality of milk from a given source. The examination of a composite sample, such as is taken for the Babcock test, should give a more correct idea of the quality than samples representing the product of a single day. The samples can be preserved with formalin and used for both fat and bacterial determinations. It is evident that the direct microscopic method is the only one applicable to such samples.

Frost's little plate method

The little plate method devised by Frost (1916) is a combination of the direct microscopic and the cultural methods. Inasmuch as it is not as well known as the ones previously discussed, a brief description of it is given. One cubic centimeter of the milk to be examined is mixed with 1 cc. of nutrient agar. One-tenth of a cubic centimeter of this mixture is spread over an area of four square centimeters on an ordinary microscopic slide, which is then incubated at 37°C. under such conditions as to prevent drying. The period of incubation ranges from four to eight hours. Following the incubation, the agar film is dried quickly, treated with acid alcohol, and stained with methylene blue. The colonies, microscopic in size, appear blue on a colorless field. They can be counted with the low power of the microscope. Knowing the area of the microscopic field and of the entire preparation, a factor can be obtained that will furnish the number of bacteria per cubic centimeter when multiplied by the average number of colonies per microscopic field. The advantages of the method lie in its rapidity, the economy of culture medium and glassware and in labor. If the preparations are examined with a high power objective, individual organisms can be seen and thus the same information obtained as to types of organisms present as with the direct microscopic count. This information is supplemented by the colonial structure. The method has one disadvantage and that is that the cultures must be incubated long enough to allow the colonies to reach a certain size, i.e., a size easily visible with the low power of the microscope; they must not be incubated too long or the colonies will be so large and crowded that counting will be difficult. It would frequently be necessary to remove the cultures from the incubator at an inconvenient hour. The plate culture and the direct microscopic methods do not have this disadvantage.

Methylene blue reduction test

The reduction test is based on the fact that the color imparted to milk by the addition of a small amount of methylene blue dis-

appears more or less quickly, depending on whether the bacterial content of the sample is high or low. The simplicity and economy of the method, both with reference to apparatus and labor, make it a most attractive one if it actually measures the bacterial content of the milk. An excellent and complete summary of the literature on this method has been made by Fred (1912).

In the development of the direct microscopic and the little plate methods, as well as in the case of the reduction test, the results obtained have always been compared with those furnished by the plate culture method for the purpose of gaining information concerning the accuracy and applicability of the method under consideration. The widespread use of the plate culture made such a comparison inevitable. It may well be asked, however, whether from such comparative tests one can gain information on which to base judgment concerning the value of a new method.

It is impossible to determine the actual number of living bacteria in such materials as water and milk in which a large variety of organisms, demanding far different conditions for their growth, is to be found. The plate culture may furnish all the information that it is necessary to obtain concerning the material examined. It seems probable that this is true in the case of water, but the information may be far from the truth as far as total numbers of bacteria are concerned. The water of the inland lake bordering the campus of the University of Wisconsin shows about 300 bacteria per cubic centimeter when the medium and temperature of incubation are those recommended in the Standard Methods for Water Examination. If Nährstoff-Heyden agar is used, the bacterial content increases to 3000 per cubic centimeter.

As mentioned previously, it is probable that the plate culture method, especially when the medium employed contains no added sugar as in the standard methods, does not determine all the kinds of bacteria that are actually functioning in the milk and thus are more or less concerned in its decomposition. The comparison of one method, which determines a certain part of the mixture of organisms present, with another method, which determines

another part of the organisms, for the purpose of gaining an idea of the accuracy of either would seem futile. It would be as foolish as to attempt to ascertain the accuracy of a method for determining chlorine in sewage preserved with chloroform, when the method determines not only the chlorine in the form of chlorides, but also that in chloroform, by comparing the results obtained with those furnished by titration of the sewage with silver nitrate which will not measure the chlorine in the chloroform. Yet this is exactly what the bacteriolorists have done in their development of methods. It would seem that a much more satisfactory way would be to do as the chemists have always done, namely make up samples of known content to which the method shall be applied and thus determine whether consistent results can be obtained. Exactly this is constantly done in making plate cultures. If a sample of milk is diluted one hundred times and if the plates inoculated with 1 cc. of the mixture show 200 colonies, then plates inoculated with a further dilution, 1–200, should show 100 colonies. The wide deviation of obtained results from the theoretical shows the fallibility of the plate method of determining bacteria.

In the case of such a material as milk, a further comparison might be made between the results obtained by the method in question and the rate of progress of the most important type of fermentation in the material under examination; for example, the acid fermentation in milk. It will be evident that such a comparison will be inaccurate since many of the organisms determined may not be concerned in the souring process. It may be shown, however, that the data obtained as to numbers may correlate in a general way with the keeping quality of the milk. The bacteria present in milk, but which do not grow therein, are of no commercial importance. A method which determines only the number that actually grow in the milk would be desirable from the practical point of view. A brief consideration of all the methods suggested for determining the bacterial content of milk would seem to indicate that the reduction method should come closer to measuring the bacteria growing in the milk than any of the other methods, for the disappearance of the color is

dependent on the growth of bacteria. It is true that the test must be made at temperatures at which milk is not handled; thus identically the same groups may not function at the temperature of the test and at that of storage.

The results obtained by all who have concerned themselves with the reduction test have shown its dependence on the bacterial content of the milk and in a general way its correlation with the results of the plate count. It has, however, been considered to give only approximate results and by many has not been thought worthy of much consideration. It has been shown by Barthel (1917) that sterile milk, freed from O_2 by heating or by passing H, N, or CO_2 through it, will reduce methylene blue in about two hours when subsequently protected from atmospheric oxygen. In other words, some constituent of the milk has a reducing action on the dye. Sterile milk exposed to the air will not reduce since the oxidizing action of the oxygen is more rapid than the reducing action of the milk. If there is some factor, like bacteria, in the milk that will use up the oxygen more rapidly than it enters from the air, the color should disappear sooner or later. If the milk alone exerts the reducing action, the minimum time of reduction should be about two hours, while if the bacteria form a reductase which also exerts an action, the reduction time might be much shorter. That this is actually the case is shown by the fact that milk of high bacterial content may reduce the dye in a few moments. Many factors may complicate the question when a comparison of reduction time and keeping quality is to be made. Milk may contain varying amounts of reductase. Bacteria vary in reducing power and in the rate at which they use up O_2 in proportion to increase in cells.

ACCURACY OF THE METHYLENE BLUE REDUCTION TEST

The data to be presented are those obtained by inoculating milk with varying amounts of sour milk or with varying quantities of a pure culture of a lactic organism. The first trial was made with well mixed, fresh, whole milk. Twenty-five cubic centimeter portions were placed in large test tubes, which were then inoculated with varying amounts of spontaneously soured milk.

Ten cubic centimeters were then removed from each sample and placed in an ordinary test tube. An aqueous solution of methylene blue was added in such amounts that the mixture represented one part of the dry dye to one hundred thousand of milk. The temperature of the bath in which the tubes were placed was 37 to 38°C. The results are presented in Table 1.

TABLE 1

The relation of amount of inoculum to the reduction time of milk

INOCULUM IN 25 CC.	REDUCTION TIME	INOCULUM IN 25 CC.	REDUCTION TIME	INOCULUM IN 25 CC.	REDUCTION TIME
	minutes		*minutes*		*minutes*
1.0	150	0.2	212	0.03	282
0.9	160	0.1	235	0.02	290
0.8	160	0.09	250	0.01	310
0.7	165	0.08	255	0.009	325
0.6	169	0.07	260	0.008	355
0.5	170	0.06	260	0.007	355
0.4	175	0.05	262	0.006	359
0.3	198	0.04	275	0.005	359

TABLE 2

The relation of amount of inoculum to the reduction time of milk

INOCULUM IN 25 CC.	REDUCTION TIME	INOCULUM IN 25 CC.	REDUCTION TIME
	minutes		*minutes*
1	108	1/200	340
1/2	140	1/1000	378
1/10	196	1/2000	393
1/20	228	1/10,000	433
1/100	323	1/20,000	438

It will be noted from Table 1 that the reduction time constantly increased with decreasing inoculum, and that it was possible to place the samples in a definite order that corresponded to the number of bacteria added.

Another sample of fresh whole milk was inoculated with varying amounts of spontaneously soured milk and the reduction time determined as before. The results are given in Table 2,

No counts of the bacteria added to the milk were made. It seems probable that the sour milk used would contain approxi-

mately 1,000,000,000 bacteria per cubic centimeter. Since this number was added to 25 cc., the number of bacteria per cubic centimeter in the inoculated milk would be as shown in table 3 in which the reduction times are repeated.

TABLE 3

Probable number of bacteria per cubic centimeter of milk and the reduction time

INOCULUM IN 25 CC.	PROBABLE BACTERIAL COUNT	REDUCTION TIME
		minutes
1	40,000,000	108
1/2	20,000,000	140
1/10	4,000,000	196
1/20	2,000,000	228
1/100	400,000	323
1/200	200,000	340
1/1000	40,000	378
1/2000	20,000	393
1/10,000	4,000	433
1/20,000	2,000	438

TABLE 4

The relation of amount of inoculum to reduction time and development of acid

INOCULUM IN 25 CC.	REDUCTION TIME	ACIDITY AFTER 96 HOURS AT 8°C.
	minutes	
1/2	150	0.57
1/4	186	0.56
1/8	197	0.51
1/16	258	0.44
1/32	303	0.33
1/64	340	0.28
1/128	355	0.24
1/256	371	0.22
1/512	403	0.20
1/1,024	411	0.19

In another trial fresh whole milk was inoculated with varying amounts of a mixture of equal parts of sour milk and water. After the 10 cc. had been removed for the reduction test, the tubes of milk were placed at 8°C. and, after ninety-six hours, acidity determinations were made. The results are presented in table 4.

It will be noted that the sequence of the series is the same, both as regards the reduction time and the acid development.

Another trial was made in the same manner. The tubes of milk were kept at 16°C. and the acidity determined after forty-eight hours. The results are presented in table 5. The results are in accord with those obtained in the previous trial in which the milks were kept at a much lower temperature for the development of acid. One discrepancy is to be noted as far as acid development is concerned.

TABLE 5

The relation of amount of inoculum to reduction time and development of acid

INOCULUM IN 25 CC.	REDUCTION TIME	ACIDITY AFTER 48 HOURS AT 16°C.
	minutes	
2	60	0.76
1	87	0.72
1/2	103	0.71
1/4	130	0.71
1/8	155	0.70
1/16	175	0.54
1/32	200	0.44
1/64	225	0.44
1/128	255	0.24
1/256	286	0.27
1/512	321	0.21
1/1,024	341	0.18

The data presented in table 6 refer to the same quantity of fresh milk, one part of which was inoculated from one sample of sour milk, another portion from a second sample. Discrepancies are again to be noted in regard to acid development in both instances. No discrepancies occurred in the reduction time. The milk used was practically free from acid-formers that could grow at 16°C. This is shown by the fact that the tubes that were not inoculated developed no or very little acid in forty-eight hours.

It will be seen from the data presented that there is a good correlation between the reduction time and the keeping quality of the milk and that both bear an intimate relation to the number of bacteria added. It will also be noted from Table 6 that a

reduction time of a certain number of minutes does not mean that a certain degree of acidity will be developed at the end of a stated time. The data of table 6 refer to a sample of raw fresh milk, which was divided and one portion inoculated from spontaneously soured milk which had been kept at 8°C. for twenty-four hours after curdling had occurred; the other portion was inoculated from another sample of sour milk which had just curdled. Both samples were placed in the water bath at the same time to determine reduction time and were kept at same

TABLE 6

The relation of amount of inoculation to reduction time and development of acid

INOCULUM IN 25 CC.	SAMPLE 1		SAMPLE 2	
	Reduction time	Acidity after 48 hours at 16°C.	Reduction time	Acidity after 48 hours at 16°C.
	minutes		*minutes*	
2	93	0.54	15	0.73
1	125	0.33	52	0.67
1/2	140	0.27	57	0.66
1/4	155	0.27	95	0.63
1/8	170	0.27	125	0.54
1/16	195	0.19	145	0.57
1/32	225	0.22	195	0.56
1/64	242	0.19	215	0.47
1/128	263	0.18	235	0.25
1/256	276	0.17	259	0.19
1/512	323	0.17	296	0.23
1/1,024	331	0.17	331	0.30
00	346	0.17	346	0.19

temperature for forty-eight hours before acid determinations were made. It will be seen that acid development in relation to reduction time has been much greater in the second than in the first sample. For example, a reduction time of one hundred and forty minutes corresponds to 0.27 per cent acid in the first sample and one hundred and forty-five minutes in the second to an acidity of 0.57 per cent. The reduction time indicates only in a very rough way the keeping quality of the milk, due to the variation in reducing power of the bacteria, variation in acid production, and ability to grow at low temperatures. Each sample

of milk will be a problem in itself as far as this relation is concerned. The writer is of the opinion, however, that the reduction test will indicate the future history of the milk as well or better than any of the other tests.

It seems evident from the data submitted that the reduction test determines the number of bacteria as accurately as can be done by any method. If the data given in table 1 are present in another form, the force of this statement may be more easily seen. From the nature of the material used for inoculating the milk, it would seem that probably about 10,000,000 bacteria

TABLE 7

The relation of number of bacteria to the reduction time

BACTERIA PER CC.	REDUCTION TIME	BACTERIA PER CC.	REDUCTION TIME
	minutes		*minutes*
10,000,000	150	700,000	260
9,000,000	160	600,000	260
8,000,000	160	500,000	262
7,000,000	165	400,000	275
6,000,000	169	300,000	282
5,000,000	170	200,000	290
4,000,000	175	100,000	310
3,000,000	198	90,000	325
2,000,000	212	80,000	355
1,000,000	235	70,000,	355
900,000	250	60,000	359
800,000	255	50,000	359

were added to each cubic centimeter of the first tube. Starting from this basis the theoretical number of bacteria in the other samples can be calculated and the data would appear as in table 7.

No one who has had experience with plate culture work would consider it possible to place in the correct order samples of milk, such as are presented, even when working with great care, to say nothing of using the ordinary routine methods. It is idle to suppose that an exact agreement can be obtained between the plate culture and the reduction test when applied to milk, due to the fact that some kinds of bacteria effect the reduction

test but do not appear on the plate cultures; and it is quite possible that some bacteria, that do not grow in the milk or at least cause a reduction of the methylene blue, may grow in the plates. It is likewise idle to suppose that the reduction test measures the total number of bacteria in a sample of milk, for, as mentioned, a few exert no reduction action and others do not grow at the temperature at which the test is made. The efforts of some to so arrange the reduction test with reference to amount of dye and temperature, so that the ratio between reduction time and the number as determined by plate cultures remains constant, show a small appreciation of the problem and extremely superficial thinking.

All the evidence which the writer has examined indicates the value of the reduction test to be as great as the value of any of the other methods discussed. As has been pointed out, each method has its advantages and disadvantages. One can best be used under certain conditions and another under other conditions. For example, the reduction test lends itself to a rapid survey. The approximate bacterial content of 200 samples can easily be determined in ten to twelve hours. Under usual conditions, there is no point in extending the observation period beyond ten hours. A water bath, some means of heating it to the desired temperature, pipettes, and test tubes make up the apparatus needed, and an aqueous solution of methylene blue the only reagent.

If the tubes of milk are kept at 38°C. for twenty-four hours, the type of fermentation will furnish additional evidence as to the quality of the milk in regard to the kinds of bacteria and something in regard to the proportion between the various groups.

Many small cities and villages feel that something should be done along the line of milk inspection. The first suggestion likely to be made to the city administration is that a fully equipped laboratory is necessary. This involves large expenditures and the employment of a worker trained in laboratory methods and in practical dairying, a difficult combination to obtain at any time. How much better it would be to employ a man who,

because of his acquaintance with practical conditions, can advise the farmers in regard to what must necessarily be done in order to improve their product after the inspector has determined by a laboratory examination the farmers who are supplying milk of low quality. This is something that can be done far better in the laboratory than in the field, for methods, not equipment, are and always have been the important thing and these are measured by the laboratory examination of the milk. Fodder stored above the stable and a manure pile close to the barn do not necessarily imply poor milk, as some would have us believe.

It seems to the writer that those engaged in milk examination should recognize that it is impossible by any method to determine but a portion of the bacteria in a sample of milk, that the results obtained are only approximations, and yet sufficiently accurate for all practical purposes as far as milk inspection is concerned.

The writer hopes to be able to present further data as to the application of the reduction test. He believes the test deserves much more attention than it has as yet received in this country.

SUMMARY

The advantages and disadvantages of the various methods of determining the number of bacteria in milk are discussed as to their applicability to raw and pasteurized milk for the purpose of determining the past history of the milk, its future history, or for control purposes either in the milk plant or by the health officials.

Original data are presented which show that the methylene blue reduction test measures with a high degree of accuracy the bacterial content of milk when applied to samples of milk, the bacterial content of which has been varied by the addition of different amounts of the same inoculum.

CONCLUSIONS

It would seem that the methylene blue reduction test may well replace the ordinary plate culture method or the direct microscopic method under many conditions.

The methylene blue reduction test measures the bacterial content of the milk as accurately as any of the methods now available.

REFERENCES

FRED, E. B. 1912 A study of the quantitative reduction of methylene blue by bacteria found in milk, and the use of this stain in determining the keeping quality of milk. *In* Centbl. f. Bakteriol. (etc.), Abt. 2, *35*, 391–428.

FROST, W. D. 1916 A rapid method of counting living bacteria in milk and other richly seeded materials. *In* J. Am. Med. Asso., *66*, 889–890.

FROST, W. D. 1916 Comparison of a rapid method of counting bacteria in milk with the standard plate method. *In* J. Infect. Dis., *19*, 273–287.

BARTHEL, CHR. 1917 Weitere Untersuchungen über die Reductäseprobe. *In* Zeitschr. f. Untersuch. der Nährungs-u. Genuss Mittel. Berl., *34*, 137.

A FURTHER STUDY OF MILK SUBSTITUTE MATERIALS IN FEEDING DAIRY CALVES[1]

R. E. CALDWELL[2]

Purdue University, Agricultural Experiment Station, Lafayette, Indiana

INTRODUCTION

No word has been more popular during the past few months than the word "conservation." Particularly is this true when it has been applied to a discussion of food products. Not for many decades has it been necessary for the great masses of our people to seriously consider the matter of conserving foodstuffs. Special emphasis has been centered upon bread-stuffs and meat. It is upon these that the fighting host depended for its daily sustenance, to a large extent. The organization of our National Food Administration has been directed at the small individual consumer as well as the public food dispensary, to save all classes of food, but more especially, those consumed by the army.

PUBLIC INDIFFERENT

Many well-informed people consider milk a perishable product used only in a limited quantity and of little significance in our present crisis. They are surprised when informed that milk and its products supply approximately 19 per cent of the nutrients consumed during normal times. When the products of the dairy represent almost one-fifth of the nourishment of our people, a new viewpoint is obtained and the business of producing milk given much more consideration. Great as

[1] A preliminary report of experimental work conducted at the Purdue Station in collaboration with Prof. Geo. Spitzer, Chemist in the Department of Dairy Husbandry, and Dr. R. H. Carr of the Department of Agricultural Chemistry.

Paper presented before the American Society of Animal Production by Professor Caldwell while Chief of the Department of Dairy Husbandry, Purdue University.

[2] Formerly acting chief Department of Dairy Husbandry, Purdue University, now Director Research and Education Department, Blatchford Calf Meal Co.

is the importance of milk in our daily diet, it still remains an undeniable fact that the lack of public appreciation for milk, butter, cheese, etc., is an indictment against our people. The average family has given little attention to the nutritive value of foods consumed. The foods served have been selected, largely, upon the basis of palatability, although habit has always had a great deal to do in directing the selection of our daily diet. Conditions are different today. It is no longer possible for the average consumer to cater to the whims of his personal taste. Food prices have forced him to discontinue in favor of the foods capable of supplying proper nourishment even though they are not so palatable, nor the thing which he is in the habit of receiving. He is also influenced by the spirit of the times and is responding to the call of our advisers, saving foods of the type suitable for long shipment and consuming more perishable products.

MILK AS A HUMAN FOOD

A more thorough understanding of the importance of milk for all classes of people, as well as the demand for economical foods has placed milk in the forefront of food products for home consumption. Even though feed prices have been extremely high and the cost of producing milk almost doubled, its public appreciation is, doubtless, upon the increase. So long as milk could be obtained at a small figure, its use as a feed for live stock was urged. In the production of pork and poultry products, as well as feed for calves, nothing has proven superior to milk. Its use for this purpose should be continued wherever possible. Especially is it important as a feed for calves, supplements being quite easily obtained for most other classes of live stock. Its use even for this purpose, however, is being questioned, not that it does not produce the desired results, but rather that its use in large quantities for this purpose is economically impossible.

The future of the dairy industry depends upon replenishing the dairy herds with the young female progeny. If they are disposed of while young in order to make the milk of their

dams available for the market, the industry will soon perish. This is not an idle dream but an existing condition. Go into any dairy district and note what has become of the calves born during the last few months. No live stock industry can long survive if the female breeding stock is not conserved.

HISTORY OF EXPERIMENTAL WORK

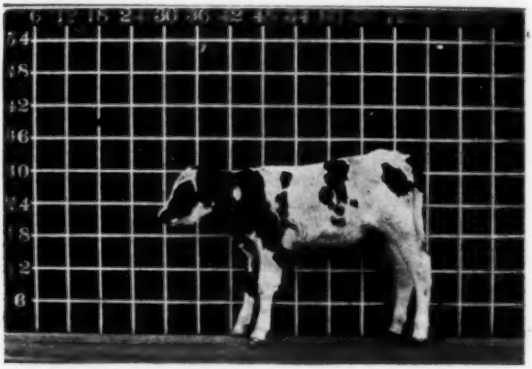
This proposition has prompted the Purdue University Agricultural Experiment Station to consider a study of substitutes for milk in the growing of calves. This work has been in progress for approximately five years. The early work was in the nature of ration tests, using milk as a basis for a comparison judging the efficiency of the ration by gain in body weight and growth. A portion of this work is reported in *Purdue Bulletin No. 193*. Our results, although not unusual, were sufficiently satisfactory to encourage us in our efforts towards securing a partial substitute for milk in the growing of calves. During the winter, 1915–1916, Mr. O. H. Anderson, a graduate student, selected the problem of calf feeding for his thesis and chose to make a digestion trial measuring the nitrogen supplied by various feeds and noting its utilization. This work was reported in the *Journal of Biological Chemistry*, vol. 28, January, 1917. The point of greatest significance in Mr. Anderson's work was the variation in nitrogen excreted by the calves when receiving various feed mixtures. A mixture which had yielded very satisfactory results during previous trial contained large quantities of dried blood. The mixture carrying this ingredient, when checked as to its final use, proved that an abnormal loss in nitrogen occurred in the feces. The use of blood in its usual dried form was, therefore, thought to be responsible for a serious loss of food elements which should have been conserved.

PLAN OF EXPERIMENTAL WORK

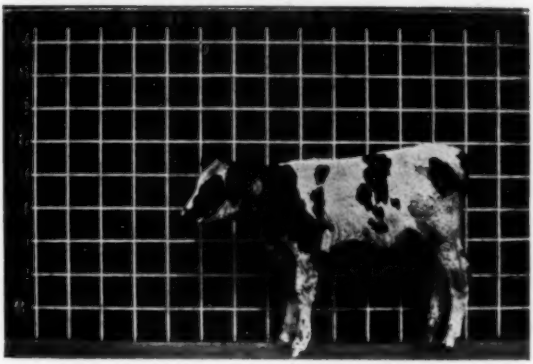
With this proposition in mind, it was decided to check the utilization of nitrogen in three rations, a ration containing liquid blood, a ration carrying only vegetable protein, and a ration composed of milk. Three lots of calves were used. The feeds fed and periods of experiment are given as follows:

Lot I

Calf 22. Received milk, ground corn and oats as a dry mash and clover hay as roughage. The milk was replaced by a mixture made up of linseed meal, red dog flour, hominy feed and liquid beef blood. The



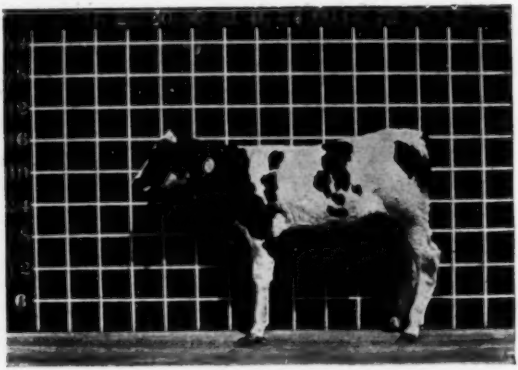
CALF NO. 22 AT 30 DAYS OF AGE. FED LIQUID BLOOD RATION



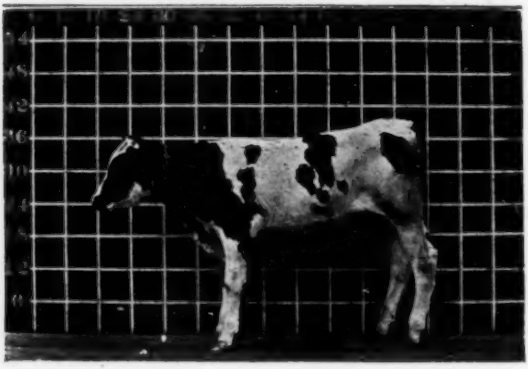
CALF NO 22 AT 60 DAYS OF AGE. FED LIQUID BLOOD RATION

ingredients in the mixture were arranged in the proportion of one part linseed meal, one part red dog flour, one part hominy and four parts liquid blood, all by weight. When the calf was 110 days of age, it was

shifted to a ration identical with the above except dried blood was used in the place of liquid blood. The four ingredients in the milk substitute were mixed equal parts by weight.



CALF NO. 22 AT 90 DAYS OF AGE. FED LIQUID BLOOD RATION

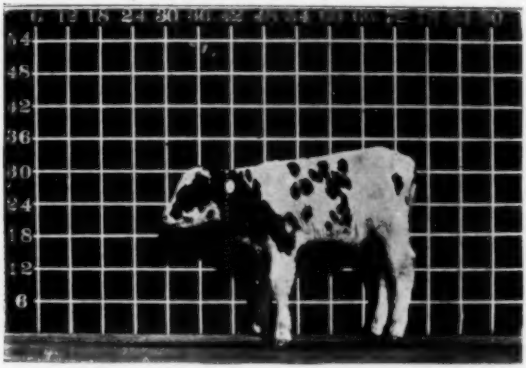


CALF NO. 22 AT 120 DAYS OF AGE. FED LIQUID BLOOD RATION

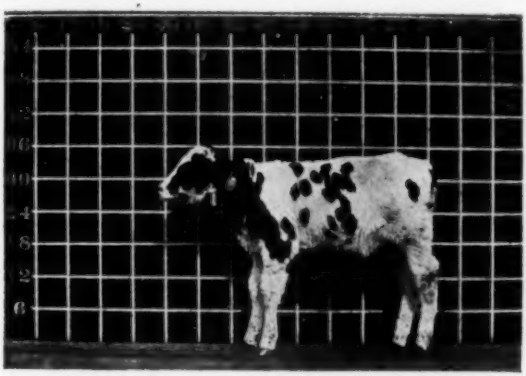
Lot II

Calf 223. Received milk, a dry mash made up of ground corn, five parts; gluten feed, five parts; red dog flour, five parts; buckwheat flour, two parts, by weight, and clover hay as roughage. The milk was

replaced by a mixture made up of the same ingredients as were fed as a dry mash with the addition of an extract obtained by boiling clover



CALF NO. 110 AT 30 DAYS OF AGE. FED THE MILK RATION

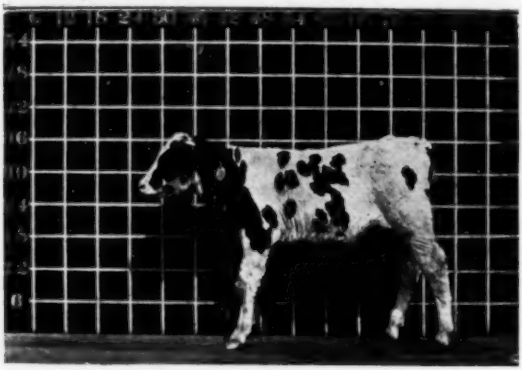


CALF NO. 110 AT 60 DAYS OF AGE. FED THE MILK RATION

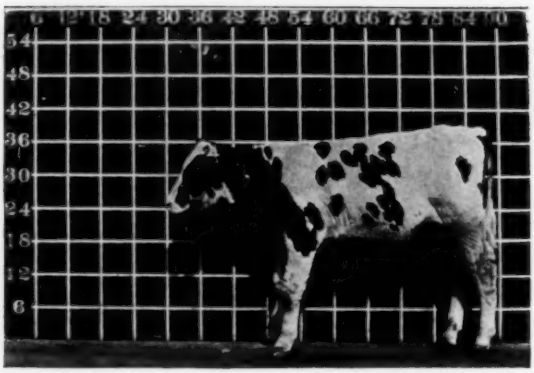
hay and water together until the liquid portion contained one-tenth per cent nitrogen. When this calf was 110 days of age, he was shifted to the ration received by calf 22 during the first part of the experiment.

Lot III

Calves 110 and 219. Received milk, ground corn and oats as a dry mash and alfalfa hay. The calves in this lot were used as a check against the ones receiving the substitute material. When calf 110 was



CALF NO. 110 AT 90 DAYS OF AGE. FED THE MILK RATION

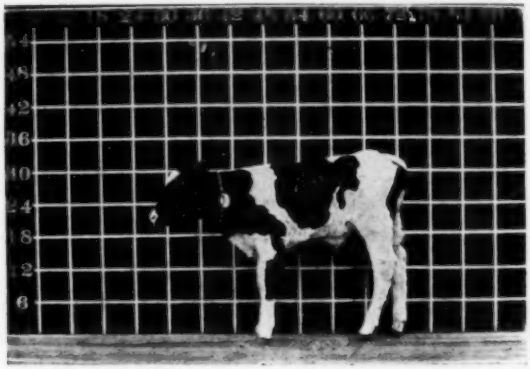


CALF NO. 110 AT 120 DAYS OF AGE. FED THE MILK RATION

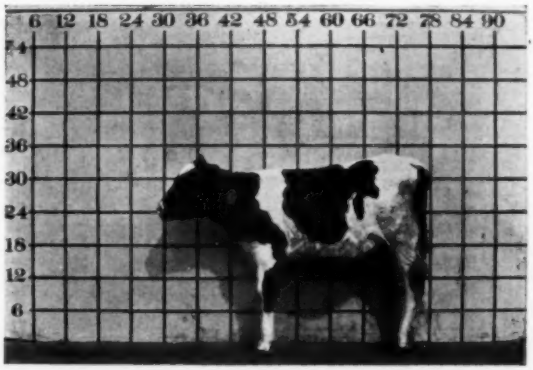
100 days of age, he was shifted to the ration received by calf 223 during the first part of the experiment. When calf 219 was 90 days of age, he was shifted to the ration received by calf 22 during the first part of the experiment.

METHOD OF PROCEDURE

All calves were placed in digestion crates and a daily record obtained as to quality and quantity of excreta produced. Reg-



CALF NO. 223 AT 30 DAYS OF AGE. FED THE CLOVER JUICE RATION

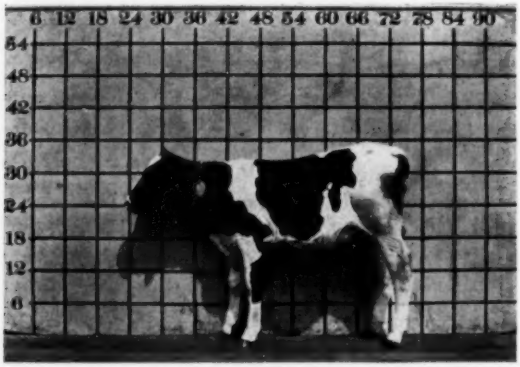


CALF NO. 223 AT 60 DAYS OF AGE. FED THE CLOVER JUICE RATION

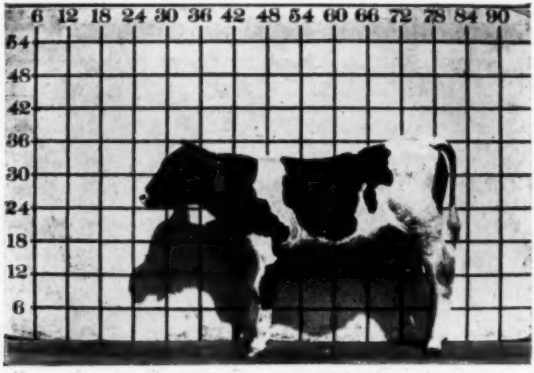
ularly, each ten days the calves were weighed and on each third ten-day period an individual photograph of the calves secured. Only grade Holstein bull calves were used.

RESULTS OF EXPERIMENT

The following tables indicate the average daily amount of nitrogen consumed by ten-day periods and the percentage supplied by each feed.



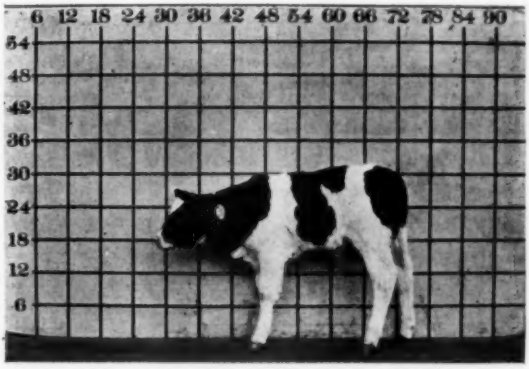
CALF NO. 223 AT 90 DAYS OF AGE. FED THE CLOVER JUICE RATION



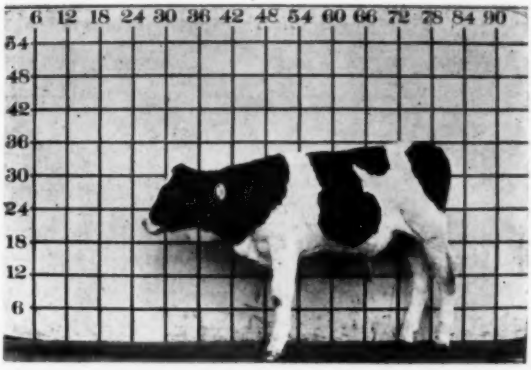
CALF NO. 223 AT 120 DAYS OF AGE. FED THE CLOVER JUICE RATION

It will be noted that calf 22 was twenty days of age when placed on test as were all except calf 219. During the first ten-day period, calf 22 received approximately two-thirds of

his nitrogen supply from milk. Milk, as a source of nitrogen, was continued for five periods although during the second and third periods, it represented only about one-third of the total amount consumed. After the third period, only a trace of



CALF NO. 219 AT 30 DAYS OF AGE. FED THE MILK RATION

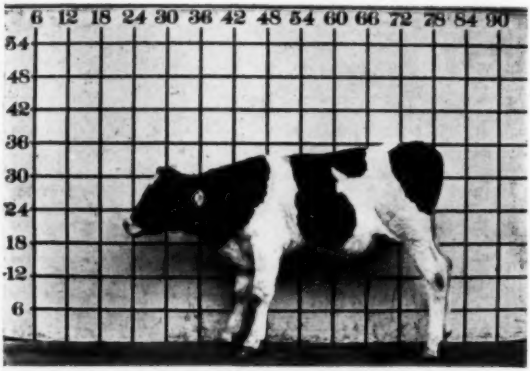


CALF NO. 219 AT 60 DAYS OF AGE. FED THE MILK RATION

nitrogen was supplied by the milk portion of the ration. In its place, as a source of nitrogen, the liquid blood increased rapidly. The blood, when combined with the meal fed in

connection with it more than replaced milk as a nitrogen carrier. The dry roughage proved to be a valuable source of nitrogen during the entire test. When calf 22 was 110 days of age, dried blood flour was gradually substituted for liquid blood and fed with the identical feeds included when the liquid blood was used. The total nitrogen intake was maintained although its source was shifted slightly.

Calf 223 received an exclusive vegetable ration with the exception of milk. Milk feeding was continued for five periods and the percentage of nitrogen supplied by it was somewhat



CALF NO. 219 AT 90 DAYS OF AGE. FED THE MILK RATION

greater than with the calf receiving liquid blood. When placed exclusively upon the milk substitute material, 60 to 70 per cent of the nitrogen was supplied by its ingredients. Calf 223 obtained a larger percentage of its nitrogen from the dry roughage than did calf 22, although the total daily intake was not as great as with the blood-fed calf. When 110 days of age, calf 223 was shifted to the liquid blood ration with a behavior quite similar to calf 22 when receiving similar feeds.

Calves 110 and 219 were used to check the substitute feeds against nature's chosen food. The quantity of nitrogen consumed daily by the milk-fed calves was quite similar to the

amount consumed by calf 223. It is also true that the percentage of nitrogen obtained from milk was not greatly in excess of that supplied by the milk substitute material fed calves 22 and 223 after the fourth and fifth periods.

TABLE 1

Showing nitrogen consumed by calf 22 and percentage supplied by each feed

AGE OF CALF	TOTAL NITROGEN IN FEED	PER CENT OF NITROGEN SUPPLIED BY EACH FEED					
		Milk	Liquid blood	Dried blood	Calf meal I	Dry mash	Alfalfa hay
days	*grams*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
20– 30	39.192	63.00	5.46		0.84	12.11	18.51
30– 40	66.152	36.38	27.63		6.56	11.84	17.59
40– 50	71.659	31.64	24.48		17.74	9.54	16.59
50– 60	105.793	6.55	48.58		33.91	3.56	7.39
60– 70	86.146	2.73	39.94		28.71	10.76	17.86
70– 80	88.671		42.45		28.89	11.45	17.21
80– 90	97.568		38.60		26.97	12.63	21.80
90–100	103.477		37.24		26.11	10.37	26.30
100–110	115.100		40.24		27.13	11.17	21.47
110–120	110.829		12.80	23.21	24.65	15.36	23.99
120–130	114.689			33.22	22.94	16.02	27.82
130–140	114.595			31.59	21.82	14.94	31.66

TABLE 2

Showing nitrogen consumed by calf 223 and percentage supplied by each feed

AGE OF CALF	TOTAL NITROGEN IN FEED	PER CENT OF NITROGEN SUPPLIED BY EACH FEED							
		Milk	Gluten mash	Clover juice	Clover hay	Liquid blood	Alfalfa hay	Calf meal I	Dry mash
days	*grams*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1– 10	38.354	60.97	17.18	3.97	17.91				
10– 20	39.878	55.03	19.34	2.05	23.59				
20– 30	35.538	28.10	32.24	10.45	29.22				
30– 40	48.876	17.31	41.10	7.82	33.78				
40– 50	48.020	3.67	48.00	12.22	36.11				
50– 60	52.917		48.50	9.15	42.35				
60– 70	55.721		48.83	10.17	40.99				
70– 80	61.183		51.56	10.26	38.19				
80– 90	58.032		60.27	11.10	28.63				
90–100	72.025		7.66	3.02	1.44	35.25	14.76	24.23	13.62
100–110	68.529					49.43	7.76	33.79	9.02
110–120	66.118					27.50	32.64	18.71	21.16

TABLE 3

Showing nitrogen consumed by calf 110 and percentage supplied by each feed

AGE OF CALF	TOTAL NITROGEN IN FEED	PER CENT OF NITROGEN SUPPLIED BY EACH FEED				
		Milk	Dry mash	Clover hay	Gluten mash	Clover juice
days	*grams*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
20– 30	27.942	85.28	5.06	9.66		
30– 40	38.677	69.69	15.01	15.30		
40– 50	47.865	65.53	14.73	19.74		
50– 60	57.238	59.93	15.85	26.21		
60– 70	60.882	57.89	16.61	25.50		
70– 80	63.365	55.62	16.69	27.69		
80– 90	67.821	51.97	20.09	27.94		
90–100	73.504	47.95	20.62	31.43		
100–110	79.417	44.08	24.25	29.74	1.86	0.06
110–120	60.461	14.38		42.93	34.29	8.40
120–130	83.808			41.19	49.98	8.83
130–140	67.944			52.72	37.14	10.13

TABLE 4

Showing nitrogen consumed by calf 219 and percentage supplied by each feed

AGE OF CALF	TOTAL NITROGEN IN FEED	PER CENT OF NITROGEN SUPPLIED BY EACH FEED					
		Milk	Dry mash	Clover hay	Liquid blood	Calf meal I	Alfalfa hay
days	*grams*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
20– 30	11.458	99.09		0.91			
30– 40	20.257	90.11	3.48	6.41			
40– 50	25.363	84.98	11.95	3.07			
50– 60	34.301	72.61	10.89	16.50			
60– 70	40.117	64.43	11.24	24.33			
70– 80	45.201	57.18	12.09	30.73			
80– 90	50.000	51.69	16.64	31.67			
90–100	59.120	45.11	18.45	35.44			
100–110	62.095	45.41	18.64	35.95			
110–120	70.784	15.93	14.75	6.60	26.39	18.22	18.12
120–130	87.232		10.53		38.90	26.55	24.02
130–140	72.541		14.39		33.92	25.39	26.30

UTILIZATION OF NITROGEN CONSUMED

The utilization of the nitrogen is the important consideration in a problem of this character. The following tables record the amount lost through the feces, through the urine, and the amount retained, all expressed in terms of percentage.

TABLE 5

Nitrogen consumed by calf 22 and its utilization in terms of percentage

AGE OF CALF	TOTAL NITROGEN IN FEED	DISTRIBUTION OF TOTAL NITROGEN CONSUMED IN TERMS OF PER CENT		
		Excreted in feces	Excreted in urine	Total retained
days	*grams*	*per cent*	*per cent*	*per cent*
20– 30	39.192	20.21	54.87	24.92
30– 40	66.152	23.73	37.50	38.77
40– 50	71.659	27.22	61.85	10.93
50– 60	105.793	31.74	43.62	24.64
60– 70	86.146	34.42	53.67	11.91
70– 80	88.671	36.71	45.53	17.76
80– 90	97.568	30.83	37.39	31.78
90–100	103.477	32.22	45.42	22.36
100–110	115.100	31.37	41.20	27.43
110–120	110.829	45.22	32.87	21.91
120–130	114.689	46.24	22.65	31.11
130–140	114.595	51.01	29.33	19.66

TABLE 6

Showing nitrogen consumed by calf 223 and its utilization in terms of percentage

AGE OF CALF	TOTAL NITROGEN IN FEED	DISTRIBUTION OF TOTAL NITROGEN CONSUMED IN TERMS OF PER CENT		
		Excreted in feces	Excreted in urine	Total retained
days	*grams*	*per cent*	*per cent*	*per cent*
1– 10	38.354	25.55	47.98	26.47
10– 20	39.878	26.87	56.75	16.38
20– 30	35.538	38.57	29.56	21.87
30– 40	48.876	40.07	20.81	39.12
40– 50	48.020	49.45	22.08	28.47
50– 60	52.917	47.99	19.45	32.56
60– 70	55.721	43.66	19.38	36.96
70– 80	61.183	45.18	15.92	38.90
80– 90	58.032	40.86	23.07	36.07
90–100	72.025	35.80	37.61	26.59
100–110	68.529	43.21	51.75	5.04
110–120	66.118	27.59	35.09	37.32

When expressed in terms of percentage, calf 22 showed a low degree of nitrogen retention. This is, doubtless, due to the fact that such an excessive quantity was consumed, that it was necessary for the body to eliminate large quantities of

TABLE 7

Showing nitrogen consumed by calf 110 and its utilization in terms of percentage

AGE OF CALF	TOTAL NITROGEN IN FEED	DISTRIBUTION OF TOTAL NITROGEN CONSUMED IN TERMS OF PER CENT		
		Excreted in feces	Excreted in urine	Total retained
days	*grams*	*per cent*	*per cent*	*per cent*
20– 30	27.942	24.40	56.42	19.18
30– 40	38.677	28.81	39.78	31.41
40– 50	47.865	31.37	37.00	31.63
50– 60	57.238	26.28	24.07	49.65
60– 70	60.882	28.05	25.09	46.86
70– 80	63.365	32.14	23.35	44.51
80– 90	67.821	28.64	31.61	39.75
90–100	73.504	27.59	26.09	46.42
100–110	79.417	26.94	23.58	49.48
110–120	60.461	39.14	33.50	27.36
120–130	83.808	36.73	19.49	43.78
130–140	67.944	42.76	33.21	24.03

TABLE 8

Showing nitrogen consumed by calf 219 and its utilization in terms of percentage

AGE OF CALF	TOTAL NITROGEN IN FEED	DISTRIBUTION OF TOTAL NITROGEN CONSUMED IN TERMS OF PER CENT		
		Excreted in feces	Excreted in urine	Total retained
days	*grams*	*per cent*	*per cent*	*per cent*
1– 10	11.458	5.92	50.53	43.55
10– 20	20.257	10.94	51.29	37.77
20– 30	25.363	12.25	41.23	46.52
30– 40	34.301	18.75	42.54	38.71
40– 50	40.117	25.10	29.86	45.04
50– 60	45.201	30.33	34.34	35.33
60– 70	50.000	27.69	26.57	45.74
70– 80	59.120	30.10	20.73	49.17
80– 90	62.095	30.08	23.87	46.05
90–100	70.784	33.01	31.94	35.05
100–110	87.232	41.32	31.35	27.33
110–120	72.541	31.34	49.16	19.50

nitrogen otherwise well adapted to tissue construction. The ratio between feces and urine nitrogen indicates a high degree of absorption and an excessive elimination of nitrogen through the kidneys. When placed on a ration containing dried blood,

calf 22 shifted from urine to feces nitrogen elimination indicating a possible lack of solubility of this ingredient.

Calf 223, receiving the vegetable ration, showed a low amount of nitrogen retention and an unusually high per cent of feces nitrogen. This is especially pronounced after the milk was eliminated from the ration and before the liquid blood was introduced. The presence of either milk or liquid blood in the ration of calf 223 caused large quantities of nitrogen to be disposed of through the urine.

Calves 110 and 219 presented a high degree of retained nitrogen. The relationship between urine and feces nitrogen is almost equal and quite constant. The substitution of the ration fed calf 223 for the milk ration fed calf 110 caused an increase in the feces nitrogen indicating a performance almost identical with calf 223 when receiving the same ration. Calf 219 when ninety days of age was fed a ration identical with that fed calf 22 during the first nine periods. The excess nitrogen increased greatly, especially with respect to that eliminated through the urine.

TABLE 9

Showing gain in body weight and record of body weights, ten-day periods

PERIODS OF EXPERIMENTS	CALF NUMBER			
	22	223	110	219
1	*pounds*	*pounds*	*pounds*	*pounds*
2	114.0			86.0
3	113.0	109.0	109.0	88.0
4	116.5	110.0	109.0	97.0
5	140.0	110.0	123.0	107.0
6	151.0	123.0	126.0	121.0
7	163.0	127.0	138.0	134.0
8	173.0	148.0	155.0	143.0
9	187.0	158.0	164.0	160.0
10	202.0	164.0	178.0	176.0
11	213.0	176.0	192.0	185.0
12	228.0	188.0	210.0	190.0
13	245.0	205.0	226.0	183.0
14	257.0	206.0	224.0	
15	275.0	198.0	250.0	
Average daily	1.15	0.68	1.08	0.81

The gain in body weight, as presented in table 9, shows a splendid performance for calf 22, a fair performance for calves 110 and 219 and a rather poor showing for calf 223. The individuals as shown in the photographs present a degree of thrift in all animals not commensurate with their gain in body weight.

The gain in body weight is the most accurate and valuable guide as to the efficiency of a ration. Although there are many characteristics of a ration which must be considered in addition to its ability to produce body gains, its efficiency in this particular cannot be disregarded. Calf 22 yielded the largest body gain and calf 223 the lowest gain. In other words, the animal protein supplied through the liquid blood stimulated greater gains than did the protein of milk. Vegetable protein was the least useful as a nutrient in the production of growth and body weight.

SUMMARY

Calf 22, receiving the animal protein in the form of liquid beef blood consumed the largest quantity, retained the lowest percentage and eliminated the largest percentage of nitrogen through the urine of any of the calves on test. The actual quantity, in grams, of nitrogen retained, however, is equal to the average of the two milk-fed calves. The excessive nitrogen eliminated through the urine, indicates a high degree of solubility or absorption of the nitrogen supplied through liquid blood and, in a measure at least, is a guide in judging the desirability of a ration for calves. When calf 22 received dried blood in the place of liquid blood, the amount of nitrogen consumed remained quite constant, the retained nitrogen was equal to that previously retained and the eliminated nitrogen shifted from urine to feces.

Calf 223, receiving the vegetable protein ration consumed a small quantity of nitrogen, retained the smallest quantity in terms of grams, and eliminated the largest quantity in terms of percentage, through the feces. The presence of milk or liquid blood increased the urine nitrogen to a point which checks very closely with the calves receiving these feeds.

Calves 110 and 219 retained the largest amount of nitrogen and maintained a more equal division of nitrogen elimination through the feces and urine than did those receiving the substitute ration. Their performance, when shifted to other types of rations was entirely consistent with the performance of calves receiving similar rations during the earlier periods of the experiment.